ID 9578
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ASTARIS LLC
Box 4111
Pocatello, Idaho 83205

February 22, 2001

Ms. Sylvia Burges
Region 10
Environmental Protection Agency
1200 Sixth Avenue
Seattle, Washington 98101

RECEIVED
FEB 23 2001

Dear Ms. Burges:

Enclosed please find the year 2000, Open Path FTIR Pond Air Monitoring System Annual Report. Per the Pond Management Plan, copies are also being sent to the Shoshone-Bannock Tribe CERCLA, RCRA Coordinator and Tetra Tech EM Inc. If you have any questions please call me at (208) 236-8330.

Sincerely,

Susan Lackey
RCRA Program Mgr.

FILED

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1239742

ID 9518
2/22/01

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ASTARIS LLC
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OP-FTIR Air Monitoring System Annual Report – 2000

TABLE OF CONTENTS

ASTARIS OP-FTIR Air Monitoring System
Annual Report - 2000

Section 1 - INTRODUCTION

This report provides the results from the ASTARIS pond OP-FTIR Air Monitoring System for 2000, the second year of operations. In addition to this introduction the report is divided into three sections. Section 2 provides a summary of maintenance and operation activities. Section 3 provides for data presentation and analysis of the data. Section 4 provides for presentation of quality assurance and control information.

The program consists of complete coverage of all sides of ponds 16S, 17, and 18 by employing two open-path FTIR (OP-FTIR) systems for each pond. On June 5th, 2000 the OP-FTIR system was removed from Pond 16S due to pond closure activities. Each OP-FTIR system scans two adjacent sides of a pond on a cyclic basis. Complete cycle time is ten minutes. (Five minutes each leg.) The Unisearch FTIR systems employed for this project are bistatic systems with one interferometer and infrared (IR) source serving two beam paths through use of a sliding mirror optical system that alternately directs the modulated IR beam to each of two receiver telescopes. Each receiver scope contains transfer optics and a mercury-cadmium-telluride (MCT) detector and is connected to the control computer and interferometer via fiber optic linkage. Each receiver also includes a liquid nitrogen auto dewer system to automatically supply liquid nitrogen as needed to the MCT detector, which operates at about 78 degrees Kelvin. Figure 1 depicts the system set-up and identifier assigned to each system beam path. Beam path elevations are set from 6 to 8 feet above grade. This is based on the need to intercept the major portion of the pond plumes and the need to be as close as practical to breathing zones while allowing for normal facility operations to proceed without extended beam path blockages occurring. The results of the OP-FTIR studies conducted previously were used to define the initial target compound and interferant compound list for the pond OP-FTIR air monitoring system. Target compounds are phosphine (PH_3), hydrogen cyanide (HCN), methane (CH_4), ammonia (NH_3), and hydrogen fluoride (HF). Interferant compounds are carbon monoxide (CO), carbon dioxide (CO_2), and water vapor (H_2O). Nitrous oxide (N_2O) will be measured for quality assurance purposes. ASTARIS has also installed a 10-meter meteorological tower (shown on Figure 1) instrumented to monitor wind speed, wind direction, temperature, pressure, delta temperature, relative humidity, precipitation, and solar insolation in the pond area vicinity. Meteorological Solutions, Inc. supplied the meteorological system. It consists of Met One sensors for barometric pressure, relative humidity, precipitation, and solar radiation; R.M. Young sensors for temperature and delta temperature; and Climatronics sensors for wind speed and wind direction. A Campbell Scientific CR23X data logger was included to record and prepare the data for transmission to the monitoring system network computer. The wind speed and direction sensors are equipped with external heaters to prevent wintertime freeze-ups. The temperature, pressure, wind speed, and wind direction signals for all six OP-FTIR systems are directly integrated into each system's spectral database via the fiber optic interface at the base station computer. All six OP-FTIR units are linked via fiber optics

OP-FTIR System Layout – Set up and Identifier

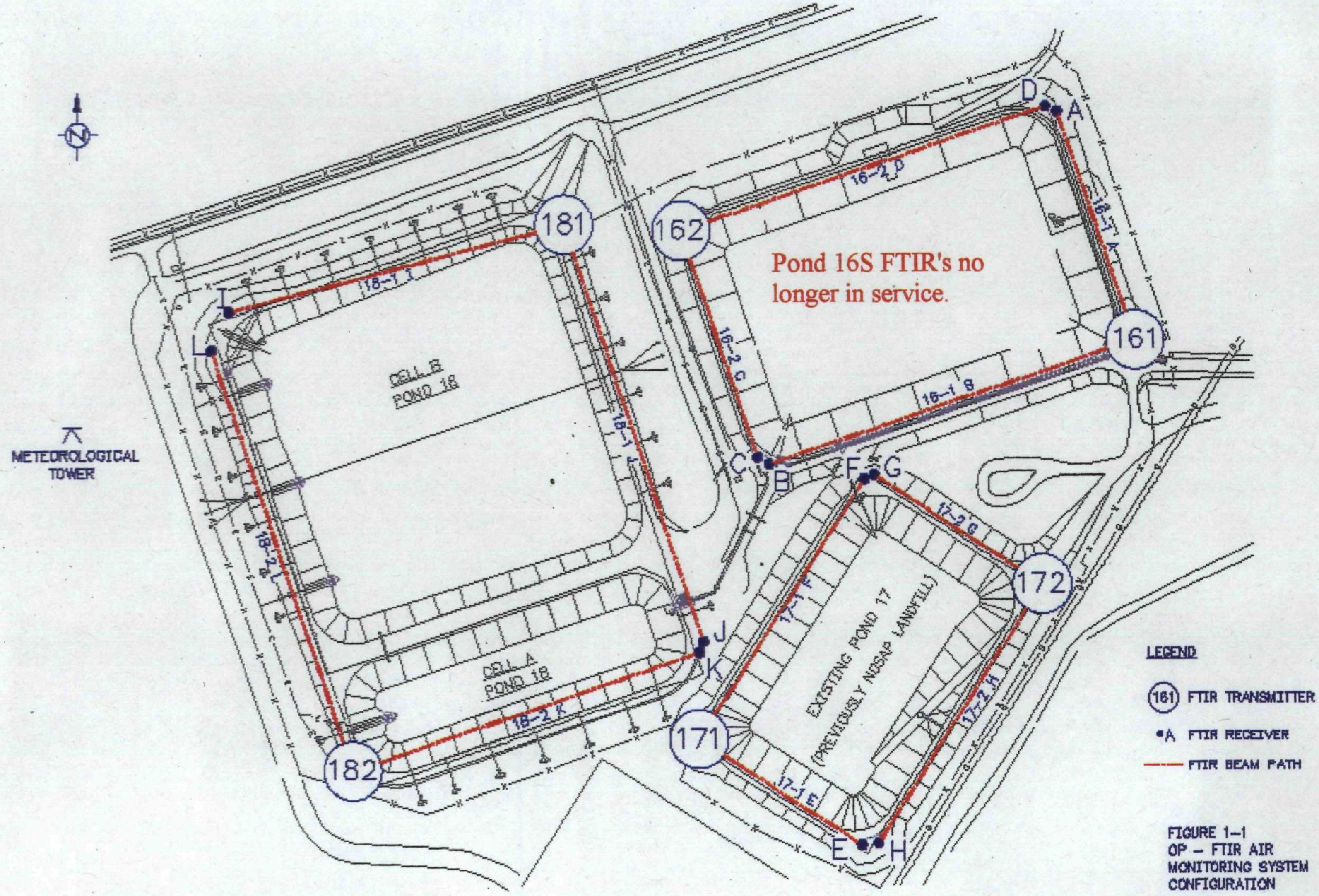


Figure 1

cable to a base station computer located in the RCRA trailer. The base PC supports a local area network (Ethernet) that polls all remote OP-FTIR units and meteorological station, extracts information, sorts and displays information, and provides for data reports compilation. The base PC is accessible via modem to provide remote data reporting access and to allow remote interrogation of individual OP-FTIR units for maintenance. A hardwire link is also in place to transmit OP-FTIR and meteorological data to the Phos Dock control room for response to readings at or above action levels.

The following are the goals and objectives set by ASTARIS management for the program:

1. 95% Annual data recovery exclusive of time required for normal maintenance, quality assurance, system start-up, and data loss due to adverse weather conditions preventing signal reception.

2. Detection of all emissions of the target compounds for this program from the active pond areas being monitored and assessment of emission changes with time and with changes in pond chemistry.

3. Maintenance and operation of the instrumentation employed in the program at levels to produce data of known quality with data accuracy goals of better than 70%, and data precision goals of better than 95%.

Section 2 - MAINTENANCE SUMMARY

2.1 Normal Operations and Maintenance

OP-FTIR site checks are performed on a daily basis both remotely and directly. Site checks are done remotely by accessing each individual OP-FTIR via a software program called pcANYWHERE32. Viewing the software screens, which are available upon remote connection, allows for the instrument status to be checked. The real time data displayed on each screen is reviewed for reasonableness of values, outliers, and data trends, which are indicative of potential malfunctions. A daily check form is filled out each day and is shown in Attachment A. The information recorded on each daily check aids in assessing any malfunctions of the OP-FTIR systems. When malfunctions of the OP-FTIR are detected, an assessment of the problem is done by directly going to the location of concern.

Direct site checks are done as follows: Liquid nitrogen auto-fill systems are inspected daily for proper functioning. Liquid nitrogen tank levels are checked daily and tanks are replaced when necessary to avoid warming of detectors, which could result in downtime for a particular instrument.

Concentration data is collected each week using pcANYWHERE32 and archived. This data is reviewed and validated by RJK Consulting on a weekly basis. Spectral data is archived on a bi-monthly basis.

FTIR DAILY CHECKLIST

Weather: Date: Time: Technician:

OP-FTIR Location	17-1-1 (E) South Beam 1	17-1-2 (F) West Beam 2	17-2-1 (G) North Beam 1	17-2-2 (H) East Beam 2	18-1-1 (I) North Beam 1	18-1-2 (J) East Beam 2	18-2-1 (K) South Beam 1	18-2-2 (L) West Beam 2
Last Status Time								
Last SCAN Time								
Maximum Voltage								
Minimum Voltage								
Bad Scans								
N_2O value								
CH_4 value								
FTIR Fail Alarms								
Data Relay OPEN								
PPA State			Comments:					

Weather: Date: Time: Technician:

OP-FTIR Location	17-1-1 (E) South Beam 1	17-1-2 (F) West Beam 2	17-2-1 (G) North Beam 1	17-2-2 (H) East Beam 2	18-1-1 (I) North Beam 1	18-1-2 (J) East Beam 2	18-2-1 (K) South Beam 1	18-2-2 (L) West Beam 2
Last Status Time								
Last SCAN Time								
Maximum Voltage								
Minimum Voltage								
Bad Scans								
N_2O value								
CH_4 value								
FTIR Fail Alarms								
Data Relay OPEN								
PPA State			Comments:					

Attachment A

2.2 Additional Operations and Maintenance Items

ASTARIS continues to refine the air monitoring system to fit the unique application of the technology for the pond areas. Additional operations and maintenance items addressed for the second year of operations 2000 can be broken down into eight major categories; analysis methods, weather, electrical, instrumentation, hardware, meteorological, software, and on stream time.

2.2.1 Analysis Methods

The analysis methods were modified a number of times throughout the year. All changes involved incorporation of different water vapor references to account for different temperature and water concentrations seen during the seasons.

The first modification to the analysis method was performed during the first part of January 2000 to accommodate the cold temperatures during the winter months.

A different quantitation method was developed and implemented during the last part of March, which reflected a change in water references to accommodate warmer spring temperatures and lesser absolute water concentrations.

A new analysis method was generated for FTIR 171 specifically because of the large shift required in the quantitation of beam path 17-1F (northwest) and was installed on May 2, 2000. In addition, a path specific water reference was generated for path 17-1F (northwest) and was found to be a better water reference then the one previously in use. This beam path had required re-quantitation of the data prior to the installation of the new method and water reference.

A new analysis method was generated and tested offsite prior to installation on the FTIR systems. The new method (Method 03) was found to work better on beam paths 17-1E (southwest), 17-1F (northwest), 18-1I (north), and 18-1J (east), and was therefore installed on these beam paths. The original method (Method 68) remained on beam paths 17-2G (northeast), 17-2H (southeast), 18-2K (south), and 18-2L (west).

Analysis methods were changed twice during the 4th quarter 2000. Method 86 was installed in October to accommodate the colder fall temperatures and Method 75 was installed early in December to accommodate the frigid winter temperatures. Both methods were installed with appropriate water references generated from pond system spectra.

2.2.2 Weather –Related Impact

Steam from Pond 18-cell A affected on stream time during January 2000 and December 2000. The temperatures for winter 2000 to 2001 were much colder than for winter 1999 to 2000; therefore, the downtime associated with the steam from Pond 18-cell A is greater for 2000 than for 1999.

2.2.3 Electrical Engineering

The periodic high intensity noise spiking on the Pond 17-2H (southeast) and 17-1E (southwest) paths was traced to the lighting fixture, which shares a common power supply with the auto-fill system. The lighting is photocell controlled and the light fixture is halogen-based, requiring a large electrical discharge for start-up. There was a lamp malfunction that prevented it from lighting but allowed continued attempts to light. This problem caused the noise-spiking pattern observed in the data. The lighting was removed from service and power supply rerouted to isolate it from the FTIR support hardware. A similar problem was noted on Pond 18-2L (west) and 18-1I (north) paths that was diagnosed and rectified with minimum data loss.

The sodium light source on the southwest corner of Pond 16S had to be disconnected during February due to a malfunction that was causing the circuit breaker to trip. The circuit breaker, which controls the auto-fill system on that corner, was affecting the on stream time whenever it would trip because the auto-fill system would not fill the detector dewers.

Periodic voltage spiking was traced to thermal expansion/contraction associated with the detector-heating element turning on and off. This was mainly seen in transition to and from winter conditions.

2.2.4 Instrumentation

Periodic telescope alignments and optical mirror cleaning were required to keep signal voltages maximized throughout the year.

The bi-annual instrument maintenance was carried out in late March and in early October, which consisted of instrument telescope alignments, internal mirror alignments on both the transmitter and receiver telescopes to gain maximum signal energy, linearity and gain adjustments as necessary, thorough optical cleaning and internal diagnostic adjustments provided by the software.

A bi-annual gas audit was performed during the month of April and again during the month of October. The results of the two gas audits can be found in the quarterly reports for the months they were performed.

A preventative maintenance schedule had been established for the detectors and commenced the first part of the 3rd quarter 2000. Maintenance has been scheduled to be on an annual basis. It will consist of exchanging all detector units with new ones on a rotating basis. Each detector that is replaced will be sent to the supplier to be serviced. It will then be returned and swapped out with another detector until all detectors have been replaced.

The two OP-FTIR units on Pond 16S were removed on June 5, 2000. The removal took approximately 5 hours and went without complication.

Default temperature was changed from 4 degrees Celsius to 12 degrees Celsius during the 2nd quarter 2000 to accommodate the warmer temperatures. This default value is used whenever the meteorological link to the FTIR systems is lost.

A performance and systems audit was carried out in May on the tower system with all parameters operating within specifications.

Noise Equivalent Absorbance (NEA) Tests were performed prior to preventive maintenance to judge whether the instruments were operating properly. This type of test is not a direct gauge of the quality of the data generated.

All heaters on the receiver ends of each beam path were adjusted to accommodate the colder temperatures towards the end of September. The heaters are crucial in eliminating any moisture that can build up on the optical window of the detectors as well as the optical mirrors.

The OP-FTIR computer's clocks were adjusted to Mountain Standard Time at the end of October 2000.

Default temperatures were changed in the Selene program during the 4th quarter 2000 from 12-degrees Celsius to 4-degrees Celsius to accommodate the colder temperatures.

2.2.5 Hardware

First Quarter 2000

Due to Pond 16S closure activities, the fiber optic hub, which was originally located in FTIR transmitter building 161, was relocated during the period to FTIR transmitter building 181. All connections were thoroughly checked and found to be functioning optimally. In addition, power lines were relocated to accommodate the closure of Pond 16S.

Two solenoid failures occurred resulting in one damaged detector for beam path 16-2C (west).

Several liquid nitrogen tanks used at the pond area had faulty pressure valves, which resulted in downtime. These tanks were promptly replaced.

Auto-fill failures had decreased substantially since the newer designed temperature probes were installed. Three auto-fill failures occurred on Pond 18 and one on Pond 16S during the first quarter 2000.

The computer monitor for FTIR 161 was replaced during January due to a display malfunction.

The computer power supply for FTIR 171 computer failed during the 1st quarter 2000. Due to the unique computer system, parts were not readily available and had to be ordered directly form the manufacturer. Several days of downtime resulted from the power supply failure.

The Optical Bench Control (OBC) board for FTIR 172 failed during the 1st quarter 2000. Only one beam path was affected by the failure resulting in downtime for that beam path.

An electrical power line had to be replaced on Pond 16S for the auto-fill system that controls beam paths 16-1A (east) and 16-2D (north).

Second Quarter 2000

The Optical Bench Control (OBC) board for FTIR 172 failed again during April 2000. The problem was isolated to a ground loop. The grounding was fixed by isolating the control board from the housing unit using nylon posts, instead of metal posts, to secure the board to the housing.

Auto-fill failures became more frequent as the weather got warmer. Re-calibrating the temperature probes, to accommodate the warmer temperatures, was necessary in several cases. Auto-fill failures decreased towards the end of the 2nd quarter 2000.

The optical sliding mirror motor on FTIR 161 failed during April. This motor was promptly replaced with several days of downtime recorded.

The power cable for the northeast corner of Pond 16S was replaced during April due to damage that was not discovered until rain entered the cable and shorted the line.

Third Quarter 2000

A computer was replaced on OP-FTIR 171 during the end of the 3rd quarter 2000. The computer that was replaced caused the Data Relay/Receiver link with the server and the Phos Dock for alarm purposes to be lost on several occasions for the two beam paths associated with that computer as well as all other beam paths. In addition, computer lock ups occurred periodically. Replacing the computer solved the problem; however, further investigation into whether the software or hardware was the problem is on going.

Auto-fill failures continued during the period and decreased towards the end of the 3rd quarter 2000. Several phase separators would not recalibrate correctly requiring refurbishing to be performed on the phase separators. The failures caused some detector damage as well.

An Optical Bench Control (OBC) board and Pre-Amp on OP-FTIR 181 were damaged during the period due to a lightning storm. The lightning strike was strong enough to completely damage the two components,.which required replacement.

Power line maintenance to the fiber optic boosters was performed during the 3rd quarter 2000 due to rainstorm damage. The damage resulted in lack of communication with the Phos Dock for alarm purposes.

A city power outage resulted in minimal downtime for the OP-FTIR systems. The OP-FTIR systems are set up to run on un-interruptible power supplies during a power outage; however, the outage lasted longer than the batteries on the UPS units.

A power line was damaged on Pond 17 during the period resulting in downtime for two Pond 17 beam paths.

Fourth Quarter 2000

All eight-receiver heaters were replaced during the period as part of the preventative maintenance program for the OP-FTIR systems. Three receiver heaters had failed during the period prompting installation of all new heaters using better heat resistant wiring.

Five detectors failed during the period. Four of the failures were on one beam path and the fifth was on the adjacent beam path. Isolating the source of the failures was difficult; therefore, solenoids and phase separators were replaced as a preventative measure.

Auto-fill failures were minimal during the 4th quarter. Re-calibrating the temperature probe was required on one auto-fill failure. A manual override of the control box was successfully performed on the remaining auto-fill failures.

High winds caused some downtime for beam path 18-2L (west) during the quarter. The receiver structure for beam path 18-2L (west) is a single receiver as opposed to the other structures; therefore, more susceptible to high winds. It is believed that the high winds are causing a vibration in the optics, which inhibits the signal from being received by the detector because the detector window, which receives the signal, is only approximately 1/16" wide.

2.2.6 Meteorological

Revision of software was necessary, which incorporates meteorological parameters, (i.e. wind speed, wind direction, temperature, and pressure), and was implemented during the first quarter of 2000. The revision was necessary due to improper averaging of wind direction when winds crossed through 360 degrees from the NW to NE or NE to NW. The scalar averaging was converting these directions to SE-SSW components. Vector averaging replaced this scalar averaging during the start of 2000.

A new data logger was installed on the meteorological tower during the month of February. A new Data Relay program was written and installed in January to allow the PH_3 and HCN data to be sent to the Phos Dock during times of meteorological tower malfunctions. The new program would use default values for pressure and temperature in the quantitation of the data. An additional revision of the Data Relay program was necessary to prevent FTIR 161 from locking up every time the server was rebooted. This was successfully accomplished late in March.

2.2.7 Software

A Y2K problem was discovered in the viewing software program called ConcView as well as the data processing software program called ConcReporter. The problems were associated with the timestamp. A revision of the two software programs was promptly generated and installed in the OP-FTIR systems. Data collection was not affected by these Y2K problems; therefore, no data was lost.

2.2.8 On Stream Time

ASTARIS has established a goal of 95% on stream time for yearly data collection. Table 2.1.1 shows monthly and 2000 annual numbers reflecting system operability. Hardware problems were the primary reason for on stream time, (detector loss and auto-fill failures), followed by maintenance and construction, and weather. Table 2.1.2 shows downtime by reason per pond.

Table 2.1.1: On Stream Time per month/per pond 2000.

Month	Pond 16 – On Stream Time (%)	Pond 17 – On Stream Time (%)	Pond 18- On Stream Time (%)
January	95.22	99.36	96.33
February	97.17	95.37	98.55
March	96.78	93.29	98.97
April	85.14	89.48	98.25
May	93.25	97.71	99.40
June	96.51	93.64	98.23
July	N/A*	98.47	96.38
August	N/A*	97.11	96.02
September	N/A*	96.68	98.00
October	N/A*	97.36	98.51
November	N/A*	98.56	98.46
December	N/A*	95.87	90.08
Annual (%)	**94.01**	**96.08**	**97.27**
Total (%) on stream time: All ponds		**96.13**	

* Not applicable - OP-FTIR systems were removed from Pond 16S on June 5th, 2000 due to pond closure activities.

Table 2.1.2: Downtime By Reason Per Pond for 2000.

Reason for Downtime	Pond 16 (%) downtime	Pond 17 (%) downtime	Pond 18 (%) downtime
Quality Assurance	0.11	0.10	0.09
Software/Hardware Maintenance	0.66	0.70	0.46
Software Problems	0.67	0.89	0.16
Hardware Problems	2.72	2.00	1.16
Construction	2.17	0.01	0.00
Empty Liquid Nitrogen Tank	0.06	0.05	0.28
Power Outages	0.00	0.02	0.01
Weather	0.00	0.14	0.59

Section 3 - DATA PRESENTATION and ANALYSIS

3.1 Summary of Annual Data

This subsection provides a summary discussion of the annual data collected on a monthly basis. Table 3.1-1 provides the average and maximum concentrations, based on hourly data, for the year by pond area for all target compounds, and Table 3.1-2 provides the exceedances for PH_3 for 2000 based on the hourly averaged data. There were no exceedances for HCN and therefore no table is provided. Figure 3.1.a, 3.1.b, 3.1.c, and 3.1.d provide the wind roses presenting wind speed and wind direction data for all four quarters of 2000.

Table 3.1-1: Maximum and Average PPM concentration values for 2000.

POND	PH3 max.	PH3 avg.	HCN max.	HCN avg.	NH3 max.	NH3 avg.	CH4 max.	CH4 avg.
16	1.22	.06	1.11	.03	.70	.02	2.60	2.01
17	2.45	.12	.96	.04	.87	.05	2.77	2.00
18	1.22	.03	.92	.04	.64	.02	3.13	2.08

Table 3.1-2: **PH_3 Exceedances for *2000* based on Hourly Averaged Data**

Legend: Concentration in Parts Per Million (PPM)
Wind Speed in Miles Per Hour (mph)
Wind Direction in Degrees from North
Ambient Temperature in Degrees Celsius

Beam Path	Timestamp	Phosphine Conc.	Wind Speed	Wind Direction	Ambient Temperature
17-1F	01/20/00 22:00	1.17	3.63	267.34	4.00
17-1F	02/05/00 21:00	1.07	1.83	319.25	4.00
17-1F	02/07/00 22:00	1.07	0.39	14.505	4.00
16-2C	03/04/00 06:00	1.07	0.14	203.9	-4.76
17-1F	04/16/00 23:00	1.14	0.93	144.92	4.08
16-1B	04/18/00 01:00	1.22	0.80	264.43	4.44
16-2C	04/18/00 01:00	1.20	0.68	263.72	4.79
17-1F	04/18/00 01:00	1.68	0.87	278.93	5.06
17-2G	04/18/00 01:00	1.17	1.07	301.79	4.95
17-1F	04/27/00 03:00	1.39	1.14	287.31	1.22
17-1F	05/04/00 22:00	1.11	0.93	135.87	9.63
17-2G	05/04/00 23:00	1.47	2.07	186.77	9.11
17-1F	05/16/00 06:00	1.10	1.29	137.56	0.26
17-1F	06/02/00 04:00	1.00	0.14	291.99	2.29
17-1F	06/04/00 05:00	1.00	1.26	156.73	4.44
17-1E	06/06/00 02:00	1.24	1.08	283.18	12.58
17-1F	06/07/00 03:00	1.11	0.68	109.26	8.10
17-1F	06/07/00 04:00	1.06	2.65	235.36	8.70
17-2G	06/29/00 02:00	1.00	4.00	203.56	14.02
17-1F	07/02/2000 0:00	1.03	0.91	155.05	13.89
17-2G	07/02/2000 1:00	1.02	2.26	234.68	11.87
17-1F	07/02/2000 1:00	1.05	1.82	228.84	11.56
17-2H	07/13/2000 1:00	1.02	1.36	301.71	18.52
18-1J	07/13/2000 4:00	1.06	1.56	165.40	10.91
17-1F	07/13/2000 4:00	1.49	2.01	161.00	11.63
17-2H	07/14/2000 3:00	1.02	1.59	290.86	10.48
17-2G	07/14/2000 5:00	1.07	1.69	257.97	9.35
17-2H	07/14/2000 22:00	1.03	0.67	109.15	20.68
17-1F	07/14/2000 23:00	1.00	13.72	319.62	31.31
18-1J	07/15/2000 0:00	1.15	0.40	239.41	13.47
17-1F	07/15/2000 0:00	2.25	0.33	108.26	13.88
17-1E	07/15/2000 5:00	1.05	1.21	354.75	10.75

17-1F	07/20/2000 4:00	1.03	1.93	220.16	8.27
17-1F	07/22/2000 4:00	1.04	1.72	179.02	9.46
17-1F	07/22/2000 5:00	1.26	0.88	244.76	7.32
17-2H	07/23/2000 1:00	1.09	0.84	342.46	15.74
17-2H	07/26/2000 0:00	1.48	1.21	213.35	22.29
17-1F	07/26/2000 5:00	1.08	1.89	114.31	14.20
17-1F	07/28/2000 2:00	1.13	1.85	107.10	15.45
17-1E	07/28/2000 2:00	1.01	1.23	112.52	15.14
17-1E	07/28/2000 19:00	1.02	3.13	56.01	33.55
17-1F	07/28/2000 20:00	1.33	2.07	78.40	29.15
17-2H	07/28/2000 21:00	1.13	3.17	132.66	23.87
17-1F	07/28/2000 21:00	1.08	2.27	134.37	23.49
17-2G	07/29/2000 2:00	1.21	0.75	212.77	13.21
18-2K	07/30/2000 1:00	1.15	1.76	80.96	14.36
17-1F	07/30/2000 1:00	1.99	1.53	68.82	16.20
17-1E	07/30/2000 1:00	1.25	1.56	78.69	15.83
17-1F	07/30/2000 2:00	1.71	1.79	159.04	12.45
17-1F	07/30/2000 3:00	1.05	1.60	67.86	12.76
17-1E	07/30/2000 3:00	1.08	1.82	64.36	13.00
17-1E	07/30/2000 19:00	1.43	4.57	49.43	34.99
17-2H	07/31/2000 0:00	1.23	0.77	227.04	23.61
17-1F	07/31/2000 1:00	1.25	2.37	118.01	20.60
17-2H	07/31/2000 2:00	1.08	2.41	182.50	18.96
17-1F	07/31/2000 2:00	1.04	2.54	172.61	19.17
17-1E	07/31/2000 2:00	1.00	2.95	165.40	19.24
17-1F	07/31/2000 4:00	1.49	0.59	183.97	15.92
17-1F	07/31/2000 5:00	1.51	0.32	182.46	13.33
17-1F	07/31/2000 6:00	1.08	1.36	104.55	13.51
17-2H	07/31/2000 19:00	1.35	1.07	266.48	36.31
17-1F	07/31/2000 20:00	2.45	4.30	57.18	30.83
17-1E	07/31/2000 20:00	1.25	4.98	52.94	30.66
17-1F	08/01/2000 4:00	1.10	0.48	214.32	15.79
17-1F	08/03/2000 6:00	1.47	1.67	224.72	19.19
17-2G	08/03/2000 6:00	1.01	1.57	228.33	18.84
17-1F	08/05/2000 6:00	1.16	1.13	160.94	10.69
17-1F	08/08/2000 4:00	1.53	1.46	92.67	12.04
17-1F	08/09/2000 4:00	1.22	1.21	174.74	16.09
17-1F	08/09/2000 7:00	1.22	0.57	71.43	14.81
17-1E	08/12/2000 19:00	1.13	4.39	55.31	30.68

17-1F	08/12/2000 23:00	1.31	1.67	120.16	16.74
17-2G	08/13/2000 2:00	1.04	2.82	230.96	9.30
17-1F	08/13/2000 3:00	1.89	2.22	167.59	9.54
18-1J	08/13/2000 3:00	1.22	2.23	177.34	9.40
17-1F	08/13/2000 4:00	1.42	0.78	326.53	8.56
17-2G	08/13/2000 4:00	1.09	0.76	182.77	8.36
17-1F	08/13/2000 5:00	1.56	0.65	291.32	7.51
17-1E	08/14/2000 1:00	1.10	0.51	220.06	14.12
17-2H	08/14/2000 1:00	1.50	0.34	246.66	14.50
17-1E	08/14/2000 2:00	1.97	0.76	316.52	12.18
17-1F	08/14/2000 2:00	1.29	0.61	330.71	11.92
17-2H	08/14/2000 2:00	1.17	1.85	321.50	12.18
17-2G	08/14/2000 3:00	1.00	2.57	310.17	9.19
17-1E	08/14/2000 21:00	1.11	1.61	99.35	18.74
17-2G	08/14/2000 22:00	1.27	1.19	152.00	19.31
17-2H	08/14/2000 22:00	1.08	1.19	152.00	19.31
17-1F	08/14/2000 23:00	1.02	0.89	241.92	11.51
17-1F	08/15/2000 1:00	1.34	2.00	133.99	11.20
17-1F	08/15/2000 2:00	1.33	0.35	90.81	10.01
17-2G	08/15/2000 2:00	1.06	2.69	159.20	13.05
17-2H	08/17/2000 0:00	1.03	1.60	275.09	17.30
17-1F	08/18/2000 23:00	1.11	1.26	245.10	14.84
17-1F	08/19/2000 0:00	1.35	1.02	176.86	11.37
17-1F	08/19/2000 1:00	1.09	1.98	336.66	12.35
17-1F	08/26/2000 5:00	1.23	1.70	179.50	14.13
17-1F	08/26/2000 6:00	1.05	1.86	257.80	15.01
18-1J	08/27/2000 6:00	1.06	0.75	110.93	15.33
17-1F	08/29/2000 4:00	1.14	2.16	34.90	14.57
17-2G	08/29/2000 5:00	1.00	1.39	189.71	7.05
17-1F	09/08/2000 1:00	1.12	1.49	157.11	9.54
17-2G	09/08/2000 4:00	1.23	1.42	83.06	4.01
17-1F	09/08/2000 4:00	1.45	1.32	101.71	3.97
17-1F	09/13/2000 19:00	1.61	2.19	152.61	24.54
17-1F	09/13/2000 20:00	1.02	1.19	108.78	18.19
17-1F	09/16/2000 1:00	1.02	0.88	246.08	13.56
17-1F	09/16/2000 2:00	1.13	0.20	175.88	11.66
17-1E	09/16/2000 2:00	1.24	1.96	100.68	12.24
17-1F	09/16/2000 4:00	1.14	1.48	110.60	8.53
17-2H	09/28/2000 16:00	1.06	2.89	274.86	26.22

17-2H	09/28/2000 17:00	1.00	3.32	260.61	25.85

3.1.1 Annual Data Discussion

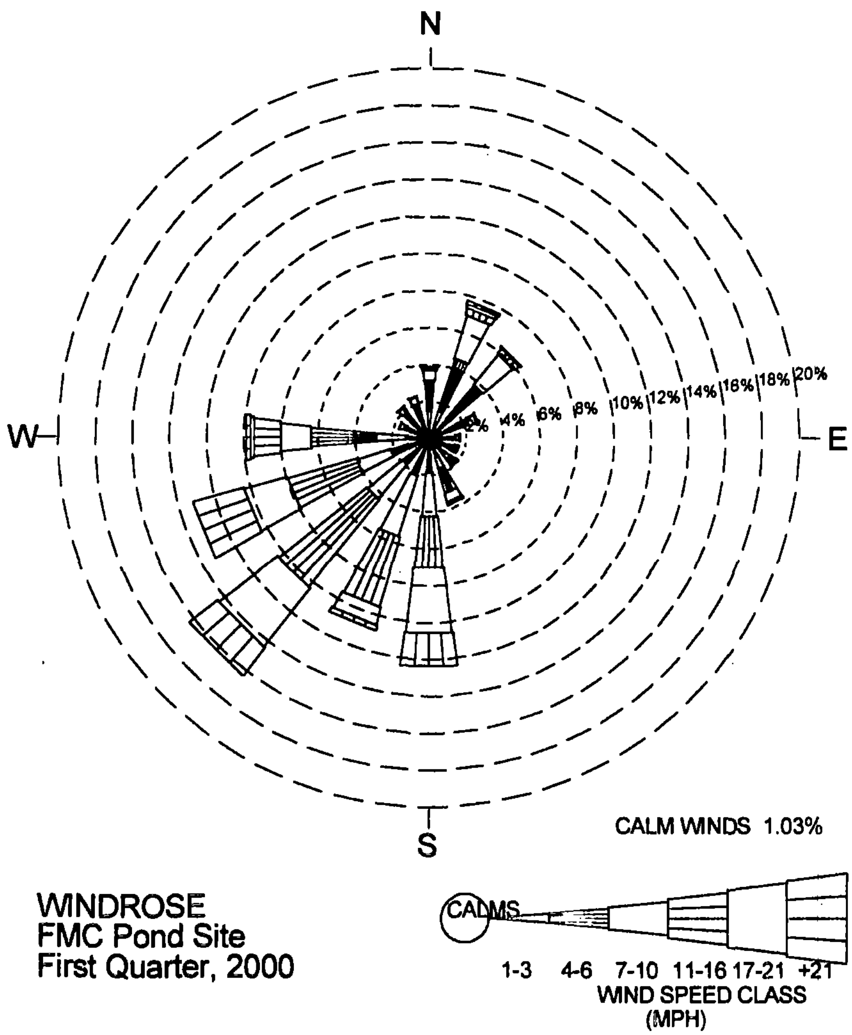
Review of maximums and annual averages for the program target compounds indicates that the highest PH_3 concentration was again seen for pond 17, and pond 17 also had the highest annual PH_3 average by a factor of two. Pond 17 had high emissions in the late spring through early October and sporadically active the rest of the time. Pond 18 showed some minor PH_3 emissions during the late spring and summer but these decreased markedly during the remainder of the year. Pond 16S showed the highest HCN concentration in April but the annual average HCN concentrations were highest and nearly identical for pond 17 and pond 18. Pond 18-cell A had high emissions levels in late spring and decreasing HCN emissions as the fall progressed, while pond 17 became a substantial HCN emitter over the late fall through winter time frame. The annual average NH_3 concentrations show pond 17 having higher emissions than ponds 16S and 18. Pond 17 has continued as a low to moderate level NH_3 source the entire year with little or no NH_3 emissions from the pond 18 area and brief NH_3 emissions during pond 16S closure activities. Most of the NH_3 impacts for the entire pond area were related to pond 17 or to impacts from non-pond sources mainly to the ENE, SE, and NW which accounted for the vast majority of all moderate to high NH_3 concentrations measured on all ponds. Somewhat higher CH_4 maximums and average concentrations were seen on pond 18 likely due to the larger train plume impacts at this location during the year, especially on the 18-1I (north) path.

3.1.2 Meteorological Data

A portion of the pond tower meteorological data [wind speed, wind direction, temperature, and air pressure] were combined with each 5-minute OP-FTIR data point through the system met-link and were archived with this data for future analysis. The pressure and temperature data were used to correct component concentrations based on reference conditions to actual conditions using the OP-FTIR operational software. The wind speed and direction data were used for producing pollution roses. The meteorological data were also archived in 15-minute segments for the year, used to produce wind rose plots, and saved for future analysis. Figure 3.1.a through 3.1.d are the wind rose plots for the four quarters of 2000.

A summary of the wind roses indicates an overall somewhat similar wind pattern for all quarters with major S to WSW sector winds and minor W and NNE-NE sector winds and fairly similar wind speed distributions. Variations seen by quarter include more major sector winds in the 1st quarter and higher winds in the 2nd quarter, and more WNW to N sector winds seen in the 3rd and 4th quarters. Calm winds only accounted for less than 0.6% of all winds during the year. Winds of 1 to 3 mph were most frequent in the 4th quarter and accounted for nearly 26% of all winds in this quarter and about 16.5% of all winds for the year.

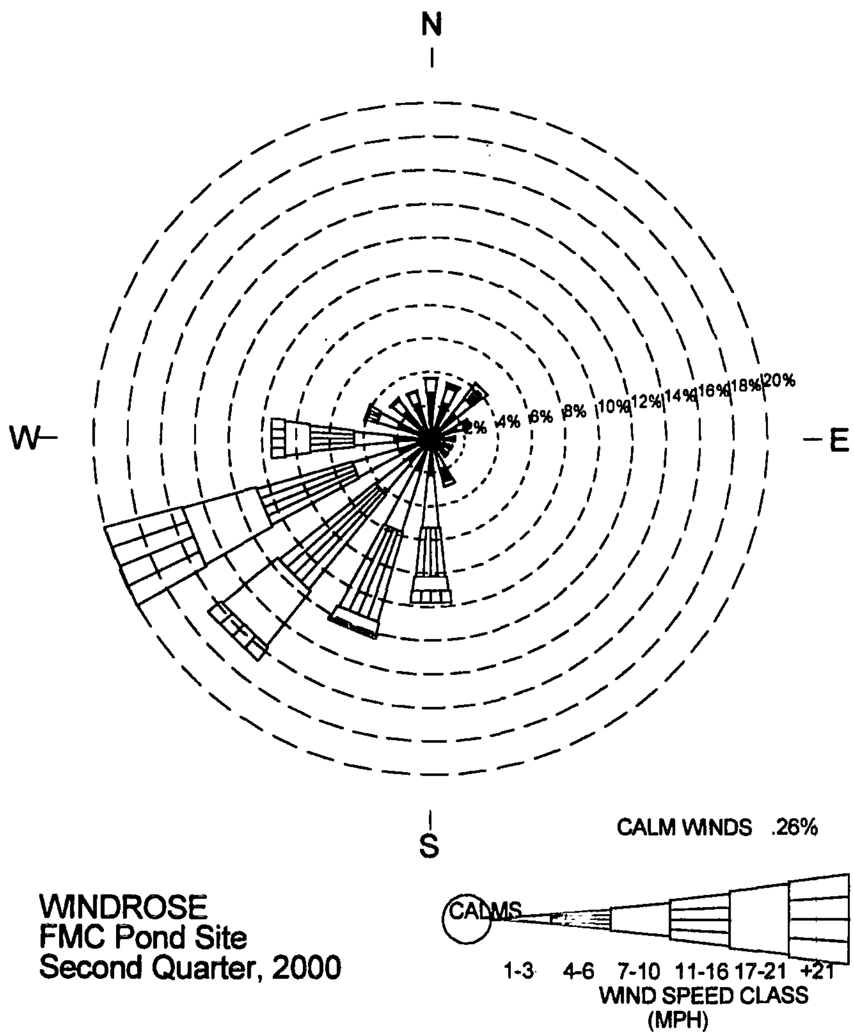
FREQUENCY OF WIND
SPEED AND DIRECTION



WINDROSE
FMC Pond Site
First Quarter, 2000

Figure 3.1.a

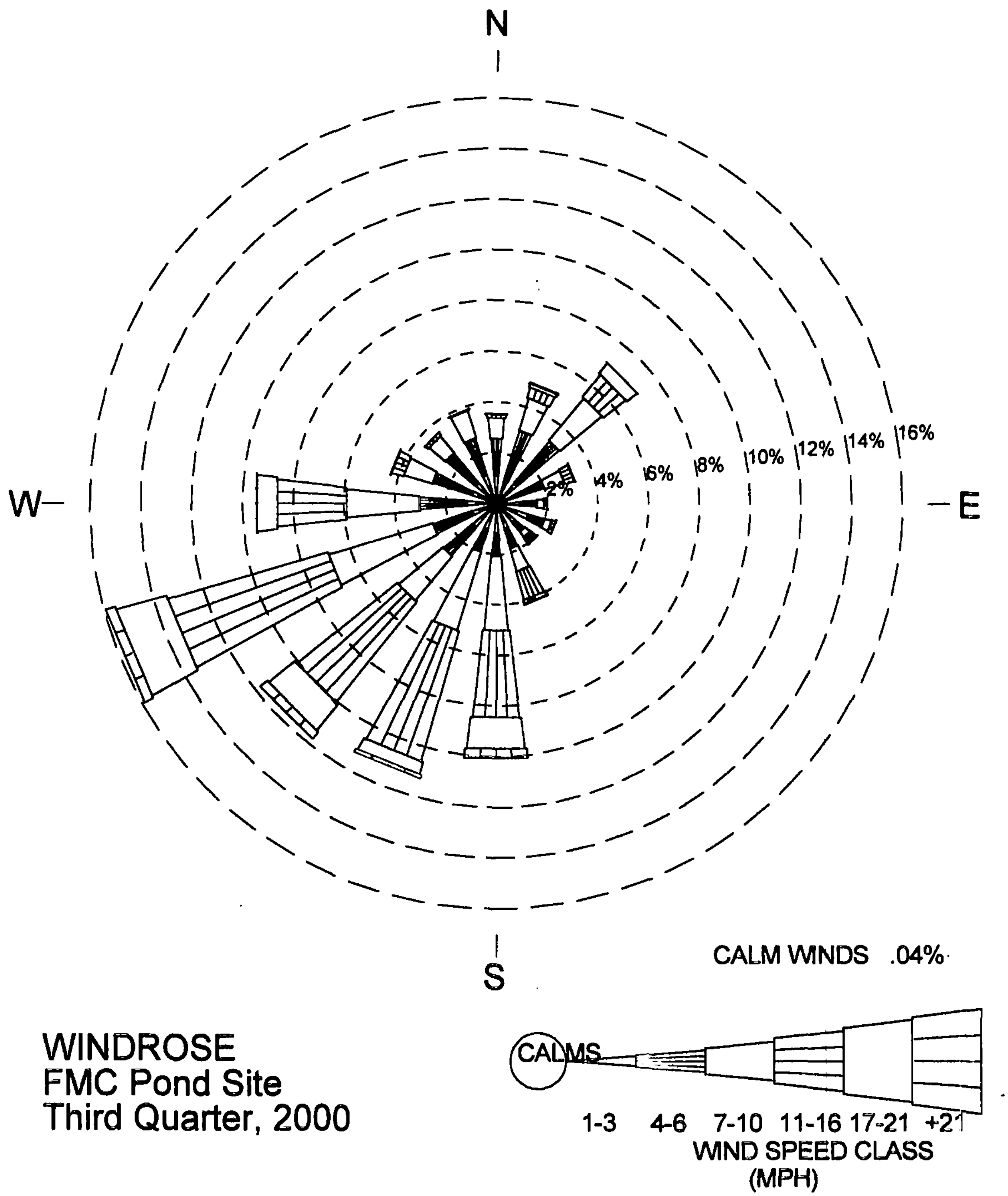
FREQUENCY OF WIND SPEED AND DIRECTION



WINDROSE
FMC Pond Site
Second Quarter, 2000

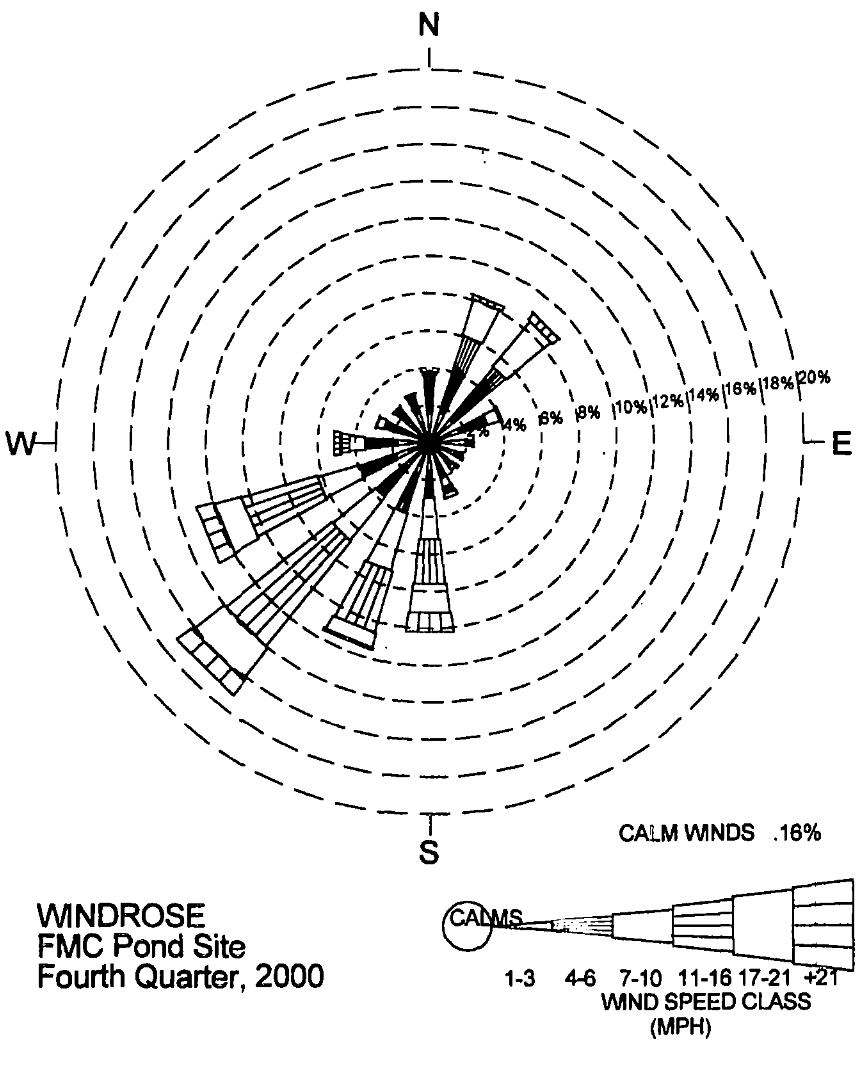
Figure 3.1.b

FREQUENCY OF WIND SPEED AND DIRECTION



WINDROSE
FMC Pond Site
Third Quarter, 2000

FREQUENCY OF WIND
SPEED AND DIRECTION



WINDROSE
FMC Pond Site
Fourth Quarter, 2000

Figure 3.1.d

3.2 Specific Data Analysis

3.2.1 Action Level Exceedances and Exceedance Evaluations

There were no exceedances for HCN during the year. The hourly PH_3 exceedances for 2000, provided by Table 3.1.2, shows the total exceedances with the vast majority [83.8 %] occurring during warmest weather months in the third quarter. There were no PH_3 exceedances seen in the fourth quarter and only four [3.6% of total] seen in the first quarter. Most PH_3 exceedances were characterized by light wind conditions typically found in the late p.m. and early a.m. hours, which allowed for build-up of pond emitted PH_3. Only 12% of all exceedances occurred when winds were non-variable [greater than 2.8 mph]. Variable meteorological conditions confined PH_3 impacts to the immediate pond area due to lack of air transport conditions. There were only a few cases seen of PH_3 build-up followed by rapid wind speed build-up to moderate levels, which allowed for transport beyond the pond boundaries prior to rapid dilution due to atmospheric dispersion. Most all of the PH_3 exceedances under non-variable winds can be directly attributed to either Pond 17 or Pond 18-cell A emission impacts with the large majority primarily due to Pond 17 emissions.

3.2.2 Annual Pollution Rose Discussions

Figures 3.2.a through 3.2.k are pollution roses that depict component-specific information and are helpful in understanding the sources and source variations for components being measured in the program. A brief discussion of the pollution roses presented follows. Note that each pollution rose provides an approximate 100% of scale value shown as part of the legend. The values shown are in Parts Per Million (PPM). Also note that some indicated values shown as due north on the figures are the result of software of defaulting wind direction that is non-functioning to north, and are not valid directions.

*Figures 3.2.a and 3.2.*b present pollution roses for two Pond 16S paths from January until early June when this pond was closed. Figure 3.2.a shows HCN impact on the 16-1A (east) path with the large majority of HCN readings seen for SSW through NW sector winds. The HCN seen originated from Pond 16S and Pond 18-cell A [SSW through W wind sectors]. Minimal HCN was seen from Pond 17 as most impacts from this pond occurred from late summer onward. Figure 3.2.b shows PH_3 impact on the 16-2C (west) path with a major portion from the NE through ESE sector due to Pond 16S. Some PH_3 impact was seen from the SE through SSE sectors from Pond 17 emissions, and minor impacts were seen from the SSW through SW sector from Pond 18-cell A.

Figures 3.2.c and 3.2.d provide pollution roses for NH_3 from Ponds 17 and 18. Figure 3.2.c illustrates the 17-1E (southwest) path and shows the large majority of elevated NH_3 from the NE due to Pond 17 emissions and from Pond 16S during pond closure operations. Impacts seen from the SE sector also originated from a portion of Pond 17 while sporadic, highly elevated impacts from the ENE, ESE, SW and NW are due to non-pond sources located in these directions. Figure 3.2.d shows the impact on the 18-2K (south) path with overall NH_3 concentrations that were lower than seen for Pond 17 paths. Most of the elevated readings were from the NE through SSE due to Pond 16S emissions during closure activities [NE sector winds], and due to Pond 17 emissions [ESE through SSE sector winds]. Minor non-pond source impacts were observed from the NW and SW directions.

Figures 3.2.e through 3.2.g provide PH_3 pollution roses for Ponds 17 and 18. Figure 3.2.e shows most of the elevated PH_3 seen on the 17-1F (northwest) path originated from the SW through ESE due to Pond 17 emissions. Some elevated PH_3 seen from the ENE likely originated from Pond 16S. Readings seen from the WNW through NW sectors were from Pond 18-cell A emissions. Figure 3.2.f shows the 18-1J (east) path primarily impacted from the ESE through SE sectors due to Pond 17 emissions. Lower PH_3 readings from the SSW through WSW sectors resulted from Pond 18-cell A emissions, while some elevated readings from the NE through ENE were likely associated with Pond 16S emissions. Elevated readings seen from the NW to N sectors were due to light and variable wind conditions. Wind speeds were less than 3 mph. Figure 3.2.g shows the 18-2L (west) path primarily impacted from the E through SSE sectors due to combined Pond 17 and 18-cell A emissions. Pond 16S also contributed to the PH_3 impacts seen during the first half of 2000 on E through ENE sector winds.

Figures 3.2.h, 3.2.i, and 3.2.j provide HCN pollution roses for Ponds 17 and 18 paths. Figure 3.2.h shows the HCN impacts on the 18-1J (east) path with most of the elevated HCN originated from Pond 18-cell A to the SSW through WSW of this path. Some elevated readings seen from the SSE through ESE sectors were due to Pond 17 emissions, especially during the second half of 2000. Minor elevated HCN impacts seen from the ENE through NE sectors were from Pond 16S emissions primarily during pond closure activities. Impacts from the NW were due to very minor and sporadic Pond 18-cell B emissions. Figure 3.2.i shows HCN impacts on the 17-1F (northwest) path. Elevated readings were seen from the SSW through ENE due to Pond 17 HCN emissions while some elevated readings seen from the WSW through NW sectors were attributable to pond 18-cell A emissions. HCN impacts originated from the NE were due to Pond16S during closure activities. Figure 3.2.j illustrates HCN impacts on the 17-2H (southeast) path with primary impacts from Pond 17 emissions seen for the SW through NW sectors. Pond 18-cell A emissions provided combined impacts with Pond 17 HCN emissions for the WNW through NW sectors.

Figure 3.2.k provides a CO pollution rose for the 18-1I (north) path of Pond 18, which was the path most impacted by CO. The majority of elevated CO concentrations occurred during winds from the NE through WNW, which are directions from the Union Pacific rail line and from interstate route 86 to the north of the rail line. Train and motor vehicle emissions were the likely source of the CO seen from these sectors. Sporadic, elevated CO readings to the WSW to S directions were from local pond area traffic or other non-pond sources, as pond-based emissions would have shown a much greater frequency of occurrence.

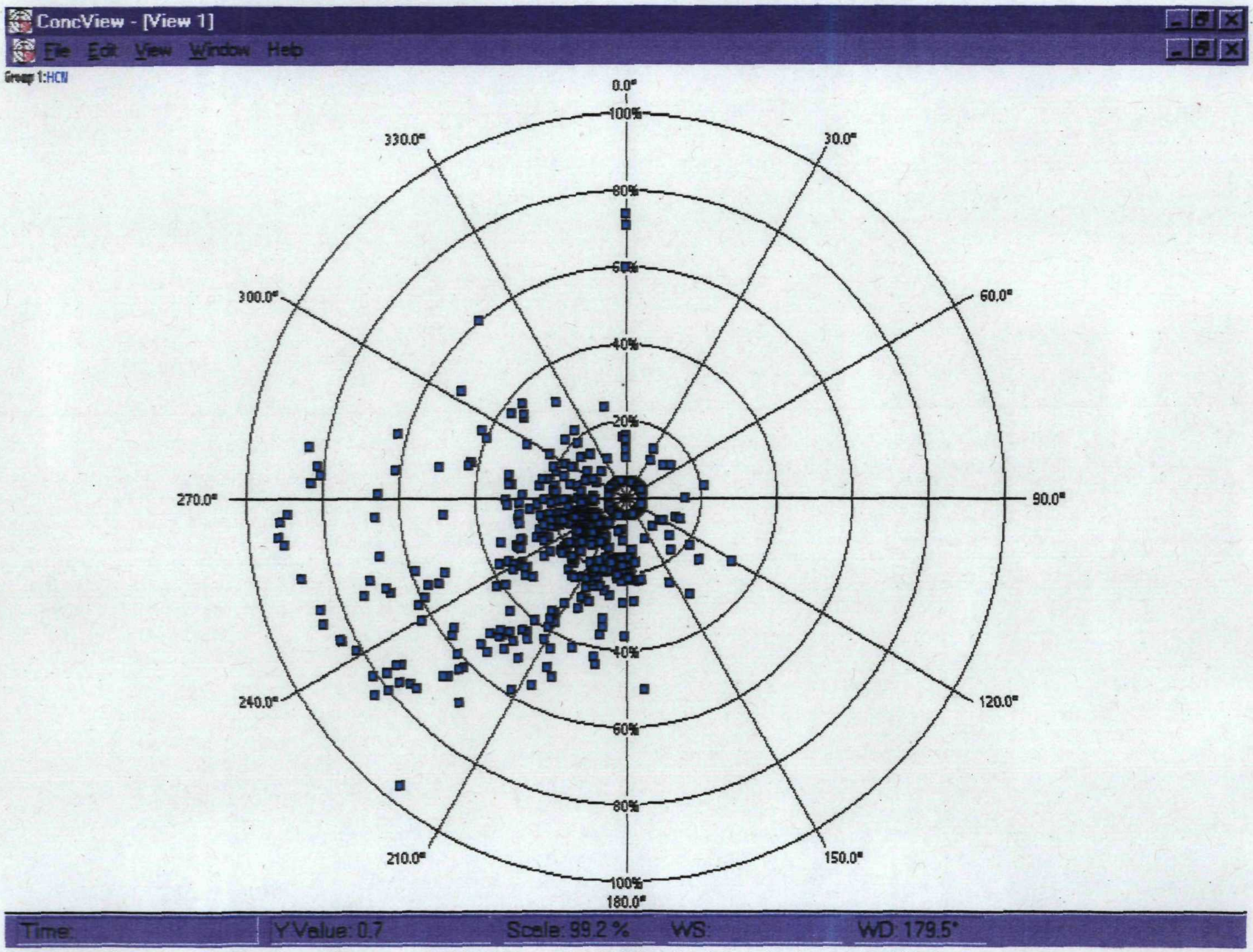


Figure 3.2.a: Pollution Rose – HCN Pond 16 [Path 16-1A (east)] 2000 Annual

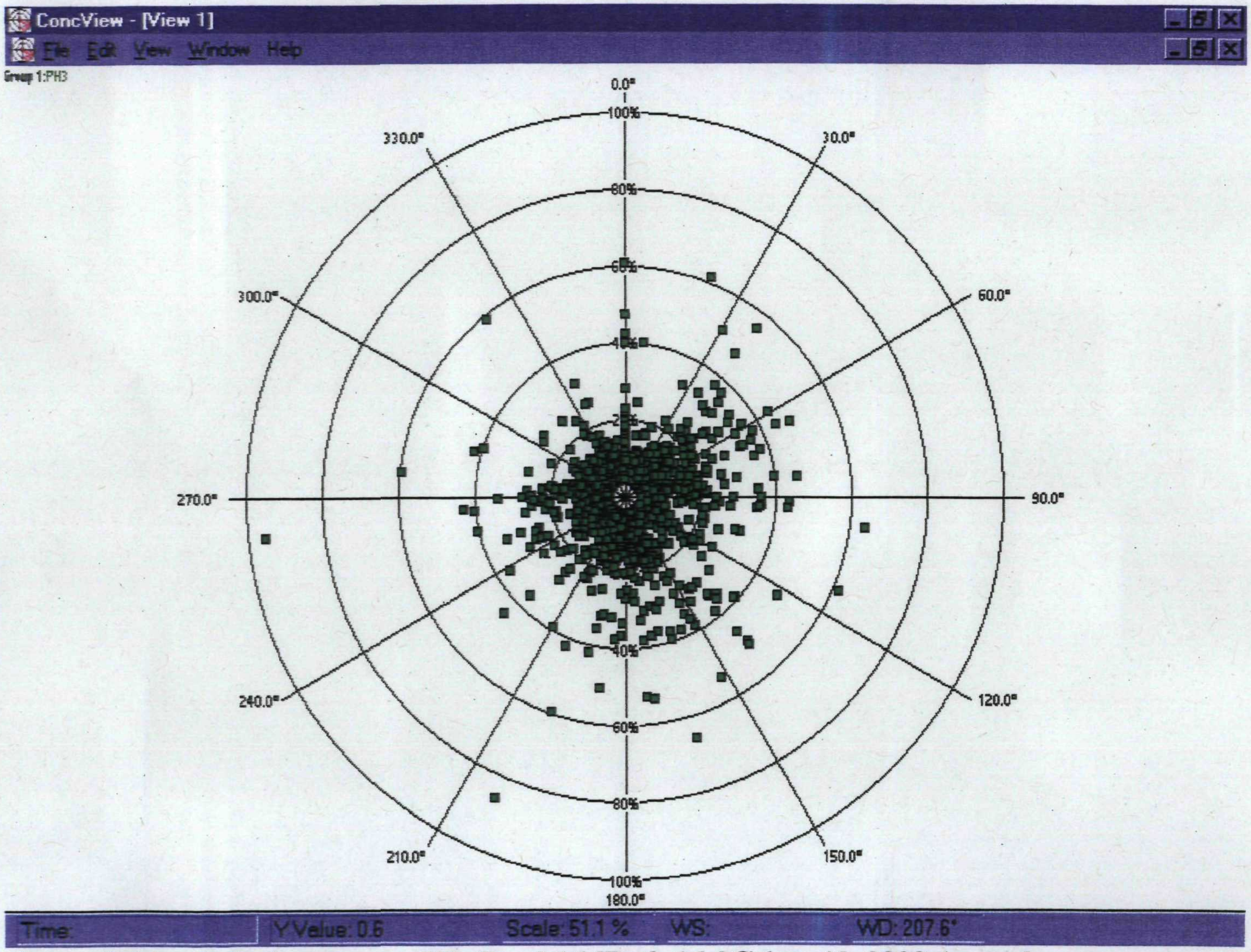


Figure 3.2.b: Pollution Rose – PH_3 Pond 16 [Path 16-2C (west)] 2000 Annual

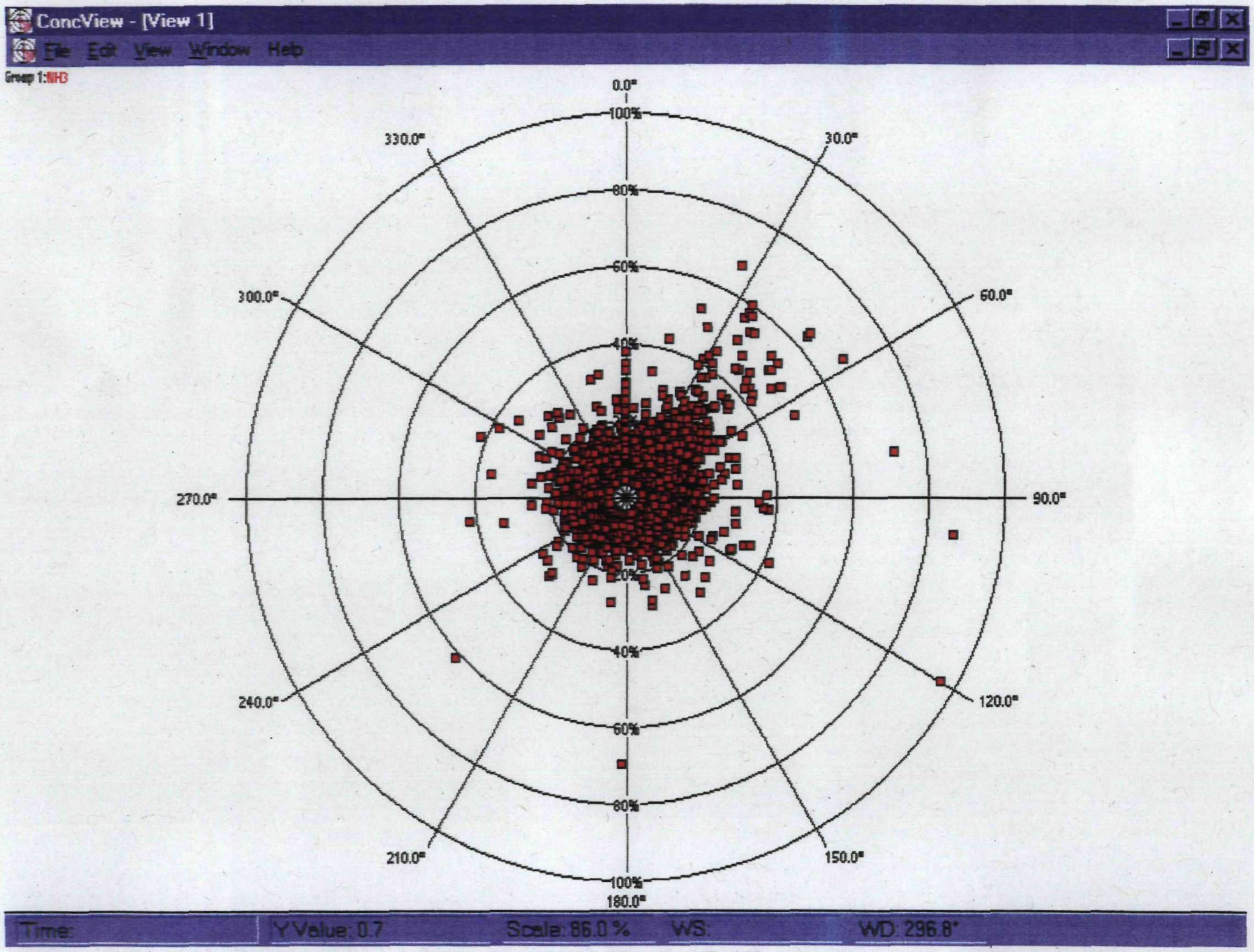


Figure 3.2.c: Pollution Rose – NH_3 Pond 17 [Path 17-1E (southwest)] 2000 Annual

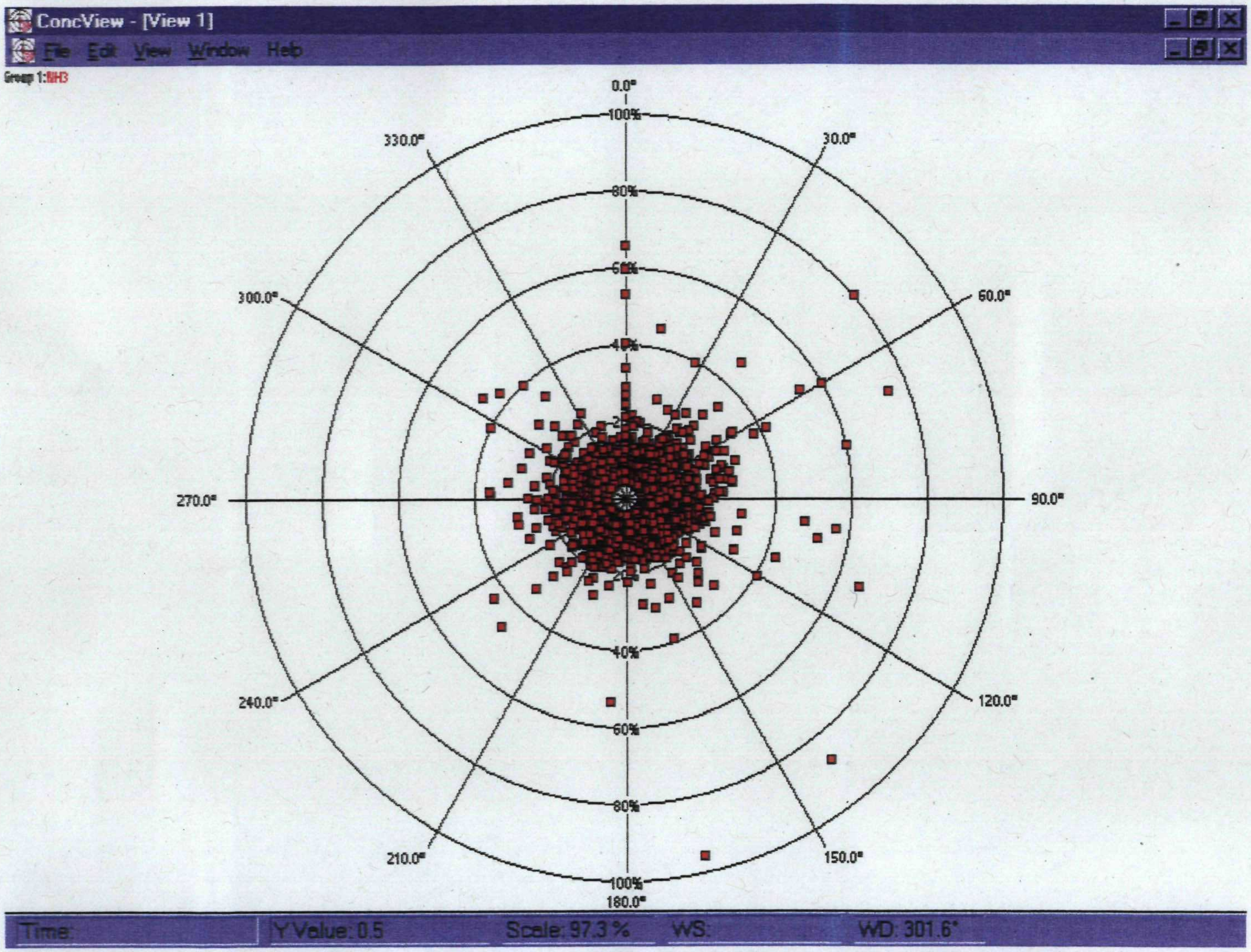


Figure 3.2.d: Pollution Rose – NH_3 Pond 18 [Path 18-2K (south)] 2000 Annual

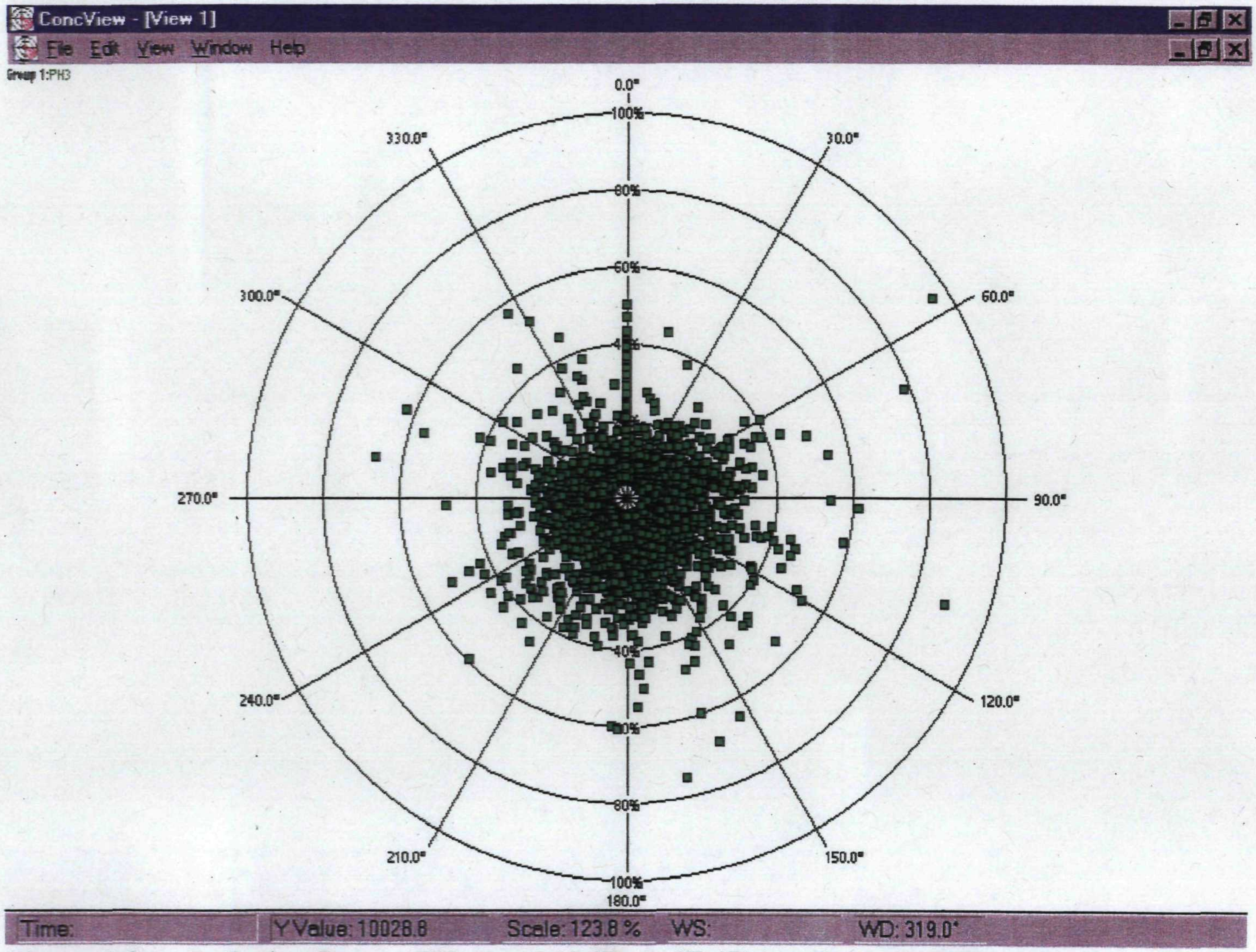


Figure 3.2.e: Pollution Rose – PH_3 Pond 17 [Path 17-1F (northwest)] 2000 Annual

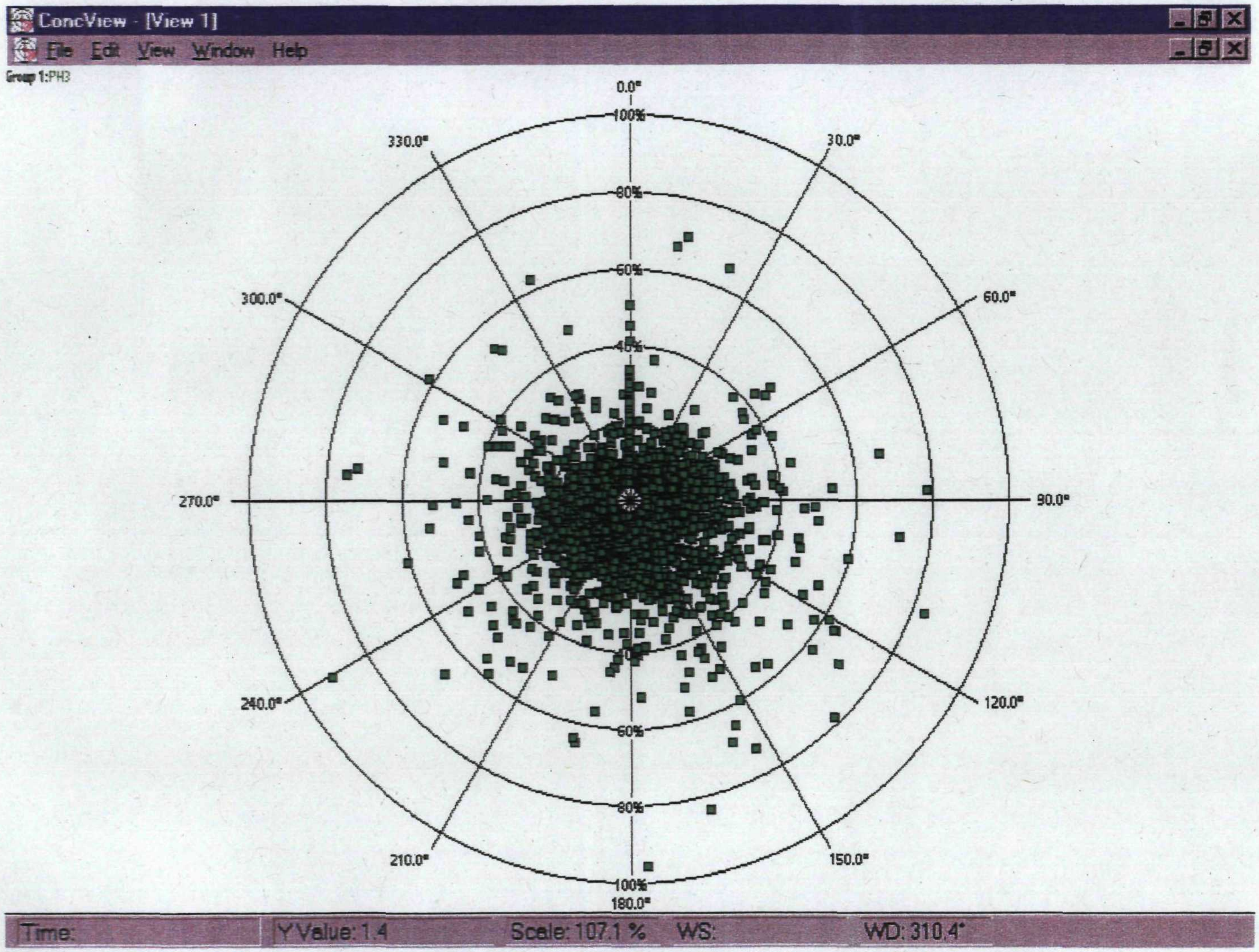


Figure 3.2.f: Pollution Rose – PH_3 Pond 18 [Path 18-1J (east)] 2000 Annual

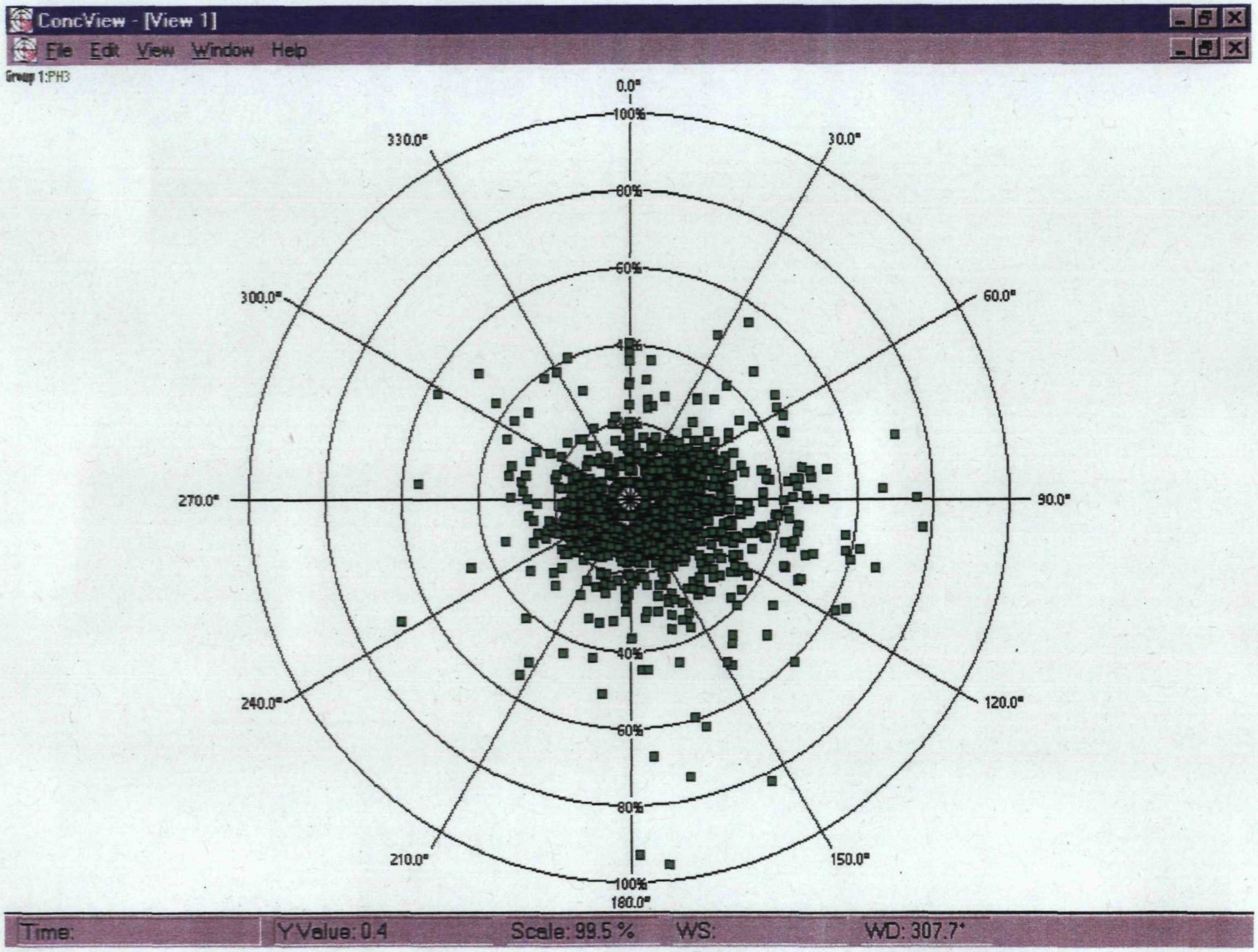


Figure 3.2.g: Pollution Rose – PH_3 Pond 18 [Path 18-2L (west)] 2000 Annual

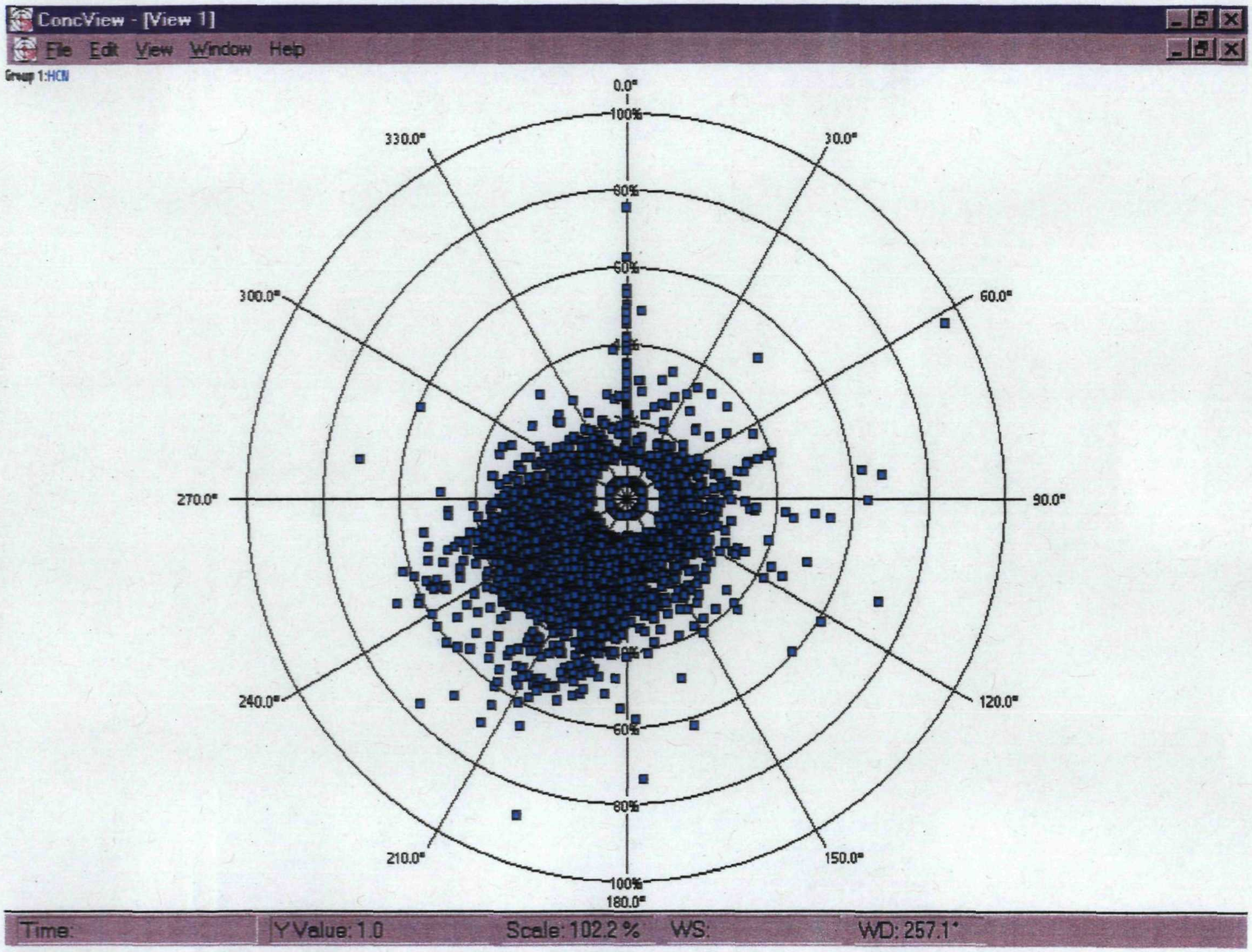


Figure 3.2.h: Pollution Rose – HCN Pond 18 [Path 18-1J (east)] 2000 Annual

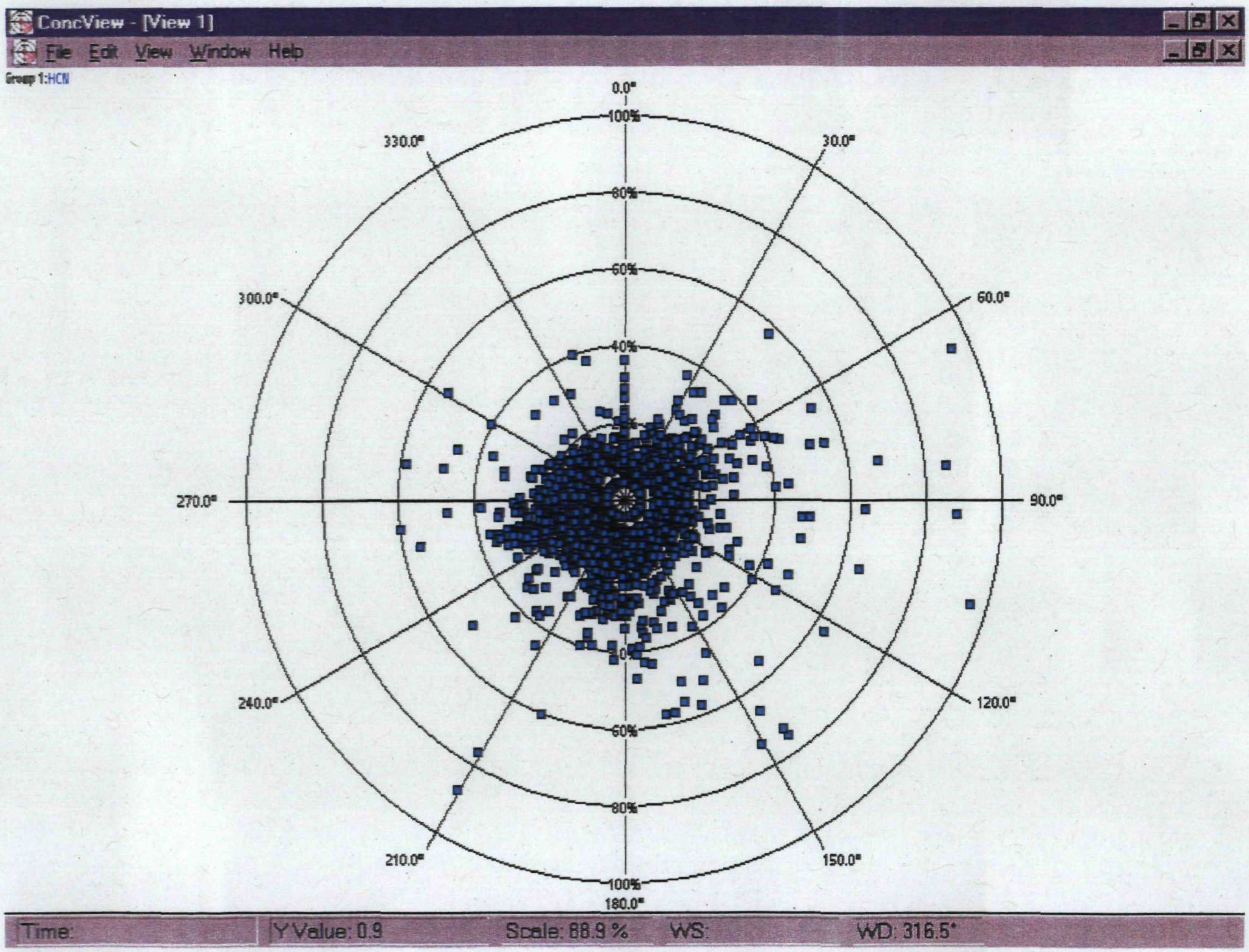


Figure 3.2.i: Pollution Rose – HCN Pond 17 [Path 17-1F (northwest)] 2000 Annual

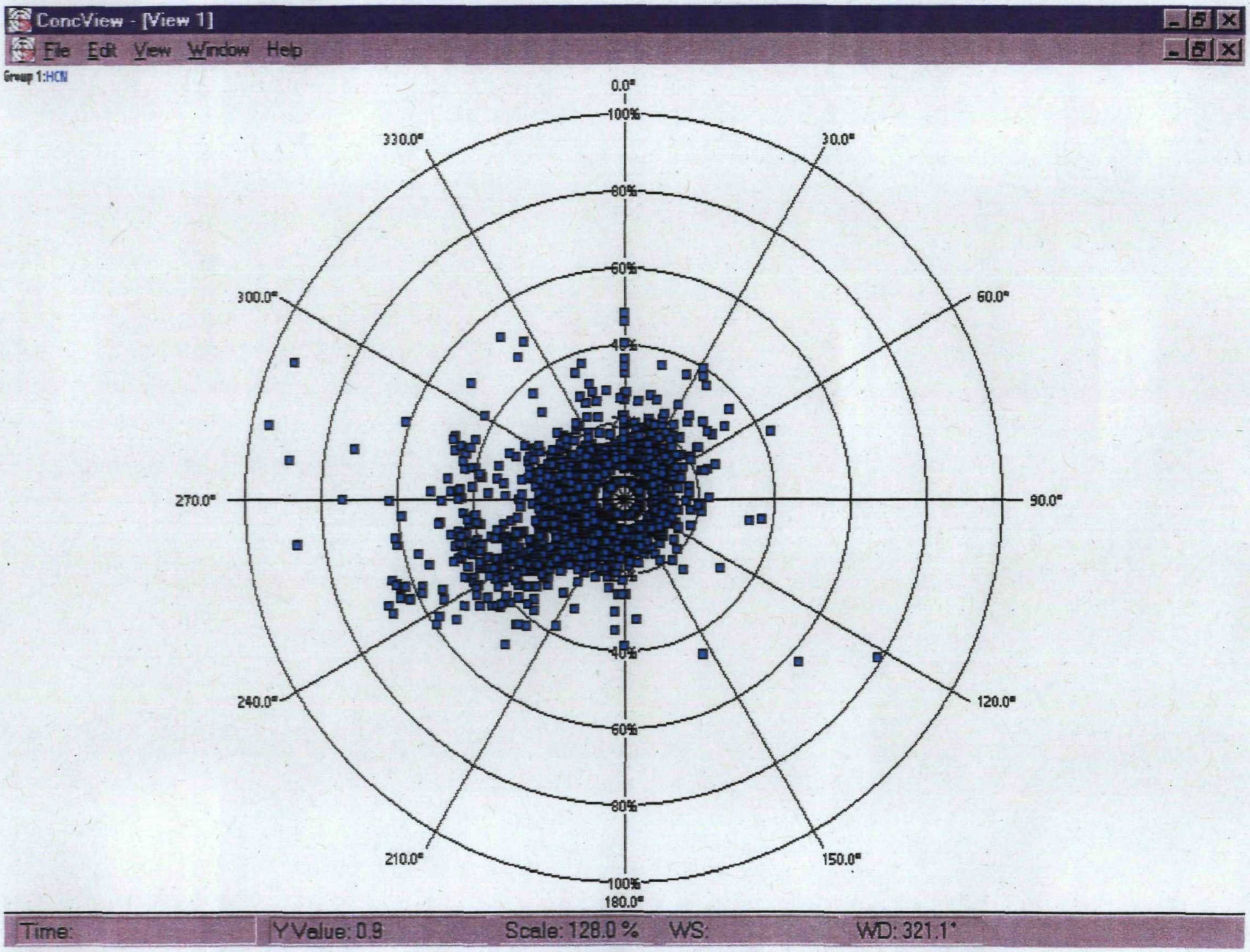


Figure 3.2.j: Pollution Rose – HCN Pond 17 [Path 17-2H (southeast)] 2000 Annual

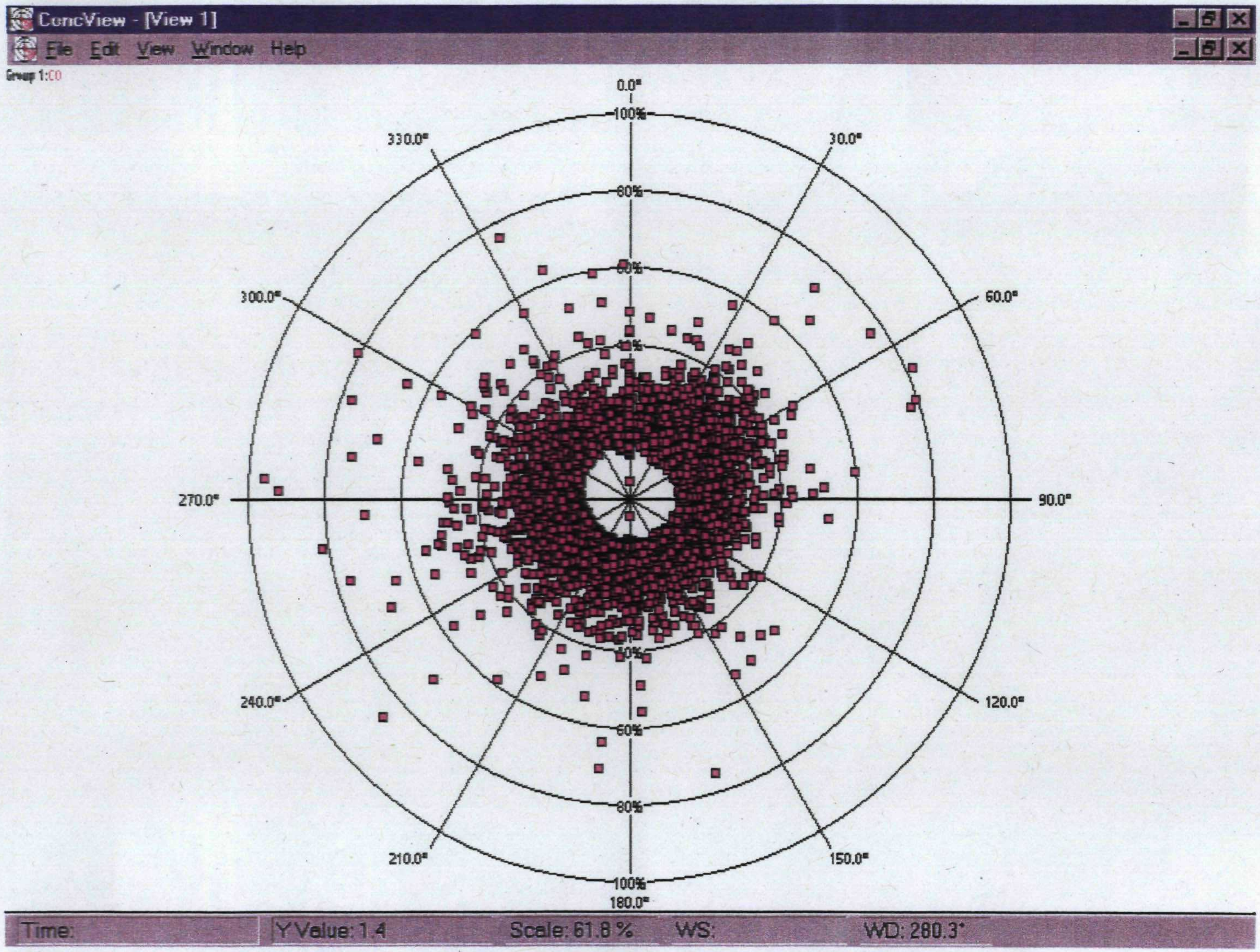


Figure 3.2.k: Pollution Rose – CO Pond 18 [Path 18-1I (north)] 2000 Annual

3.2.3 Hydrogen Fluoride Assessment

The following table indicates the working detection limits [WDL] for hydrogen fluoride (HF) in spectra reviewed for quality assurance purposes. Data spectra refer to those spectra that were part of the validated data set. Differential spectra refer to spectra that were formed using another data spectra as background to reduce the impact from baseline curvature, water vapor, and carbon dioxide.

Month	WDL range-data spectra	WDL range-differential spectra
January	.013 - .186 PPM	.014 - .175 PPM
February	.021 - .203 PPM	.010 - .126 PPM
March	.018 - .268 PPM	.008 - .122 PPM
April	.018 - .343 PPM	.008 - .143 PPM
May	.026 - .336 PPM	.010 - .159 PPM
June	.033 - .148 PPM	.014 - .063 PPM
July	.023 - .214 PPM	.010 - .067 PPM
August	.018 - .252 PPM	.012 - .103 PPM
September	.019 - .191 PPM	.009 - .105 PPM
October	.014 - .247 PPM	.011 - .130 PPM
November	.030 - .159 PPM	.011 - .103 PPM
December	.030 - .249 PPM	.016 - .139 PPM

There were five confirmable detections of HF during the year from over 900 spectra reviewed. There were four other tentative detections that were not confirmed by visual inspection of the spectra. Most HF detections or tentative detections occurred in the warmest months. The concentration range for the detections were 0.015 to 0.033 PPM and they were all seen in differential spectra. Due to the infrequency of detections and pond chemistry, Ponds 16S, 17 and 18 are unlikely sources for HF. The gyp-stack pond to the southeast of the Astaris facility is a candidate source for the HF seen.

Section 4 - QUALITY ASSURANCE

4.1 General Discussion

Quality assurance for the program includes data evaluation using TO-16 parameters on an on-going and interactive basis. Evaluation results may dictate the need for instrumentation maintenance or adjustment. QA/QC also includes some cursory data validation on a weekly or semiweekly basis, and semiannual system and performance audits. The data from the audits was used for data precision and accuracy assessment.

Weekly the OP-FTIR data was independently reviewed using the Unisearch ConcView software program. This software allows for rapid cursory review of the entire weekly data set. The results of the review were used to flag periods of marginal or unacceptable data for evaluation and to provide information for corrective actions.

4.2 Spectral Validation

A minimum of one spectrum and in most cases two or more spectra per operational beam path were independently validated each week to confirm instrument acceptability, target compounds present, and concentrations of key target compounds. The results of the review were used to flag periods of marginal or unacceptable data for evaluation and to provide information for corrective actions.

Concentration values were verified by use of alternate FTIR analyses methods/regions than used for the ASTARIS program or by calculating the area under a data sample peak and comparing this area to the area under the same peak for a reference spectrum of known concentration. The ratio of areas and pathlengths times the known reference concentration value yields a calculated data spectrum concentration.

Additionally some differential spectra were formed from sample spectra close in time or in water vapor concentration for a beam path location but with moderate to significant differences in some target compounds. Because water and CO_2 match up very well the resultant absorbance spectra have much better resolution of remaining components and much lower working detection levels for compounds. The differential spectra were used to confirm some target compound concentrations, and to check for the presence of unidentified peaks from other possible compounds.

4.3 Nitrous Oxide (N_2O) and Delta Voltage

N_2O and delta voltages were looked at on a daily basis and were used to confirm suspect or invalid data periods. These periods were investigated and data invalidated as necessary. Corrective actions were taken for any problems identified. Values exceeding ~15% deviation from the mean were investigated for N_2O and values of less than 1.0 volt delta voltage were investigated. The absolute value of N_2O is extremely sensitive to background; therefore the mean value will be different for each background.

Figures 4.3.a, 4.3.b and 4.3.c depict Nitrous Oxide for the year 2000 on a daily averaged basis. *Figures 4.3.d, 4.3.e and 4.3.f* depict Delta Voltage for the year 2000 on a daily averaged basis.

Figures 4.3.a, 4.3.b, and 4.3.c depict changes in N_20 values for Ponds 16, 17, and 18. The changes to the N20 values occurred when either new background files were generated, or a quantitation method was changed. These modifications occurred during the months of January, March, May, October, and December.

Major telescope alignments were performed in March during the semi-annual instrument maintenance. These alignments can be seen as an increase in delta voltage in *Figures 4.3.d, 4.3.e, and 4.3.f.* Additional alignments wee performed in late May. Other increases observed in *Figures 4.3.d, e, and f* were from optical cleaning and minor telescope alignments. A major alignment was performed on 17-1E (southwest) during

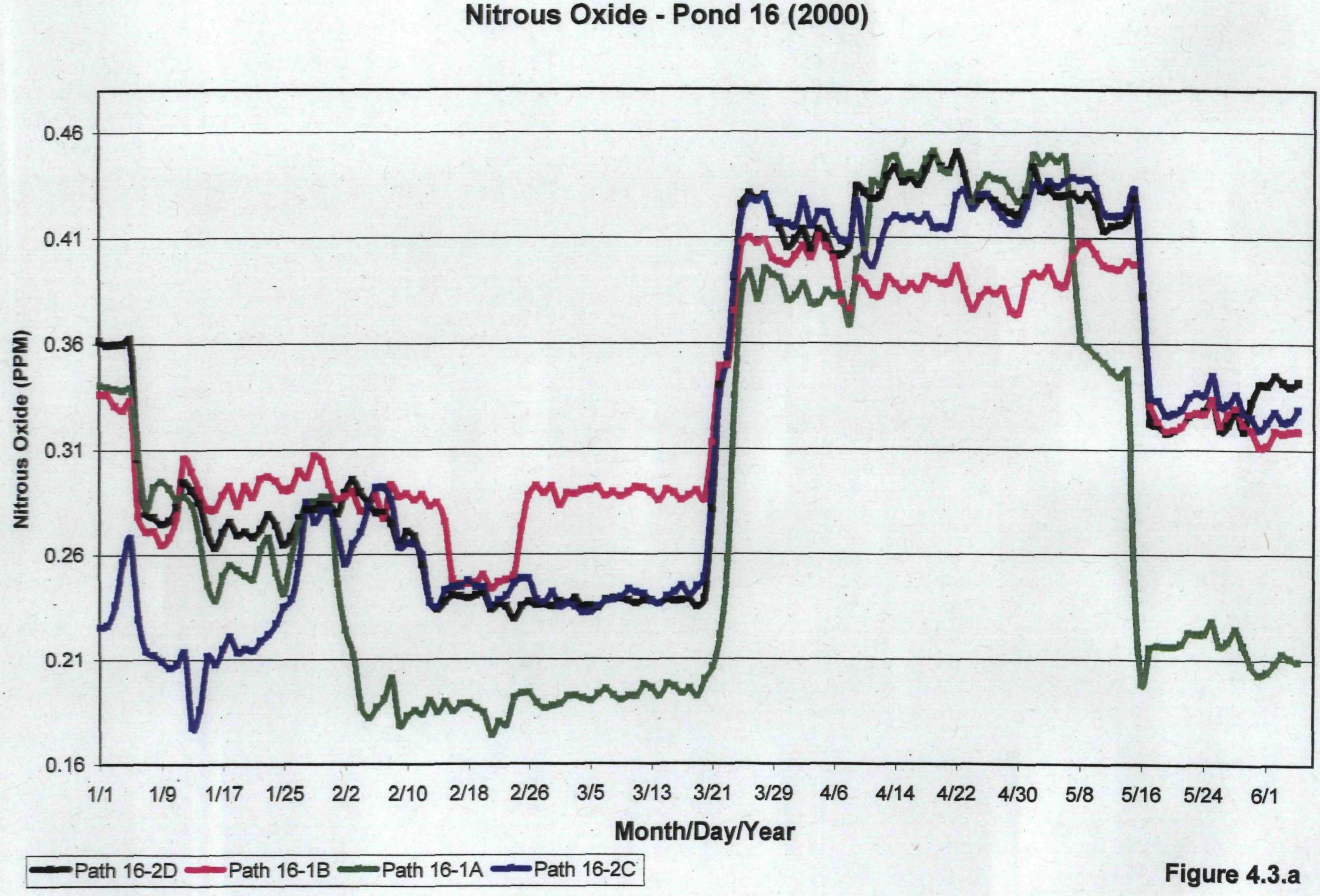

Nitrous Oxide - Pond 16 (2000)
0.46
0.41
0.36
0.31
0.26
0.21
0.16
Nitrous Oxide (PPM)
1/1
1/9
1/17
1/25
2/2
2/10
2/18
2/26
3/5
3/13
3/21
3/29
4/6
4/14
4/22
4/30
5/8
5/16
5/24
6/1
Month/Day/Year
Path 16-2D
Path 16-1B
Path 16-1A
Path 16-2C

Figure 4.3.a

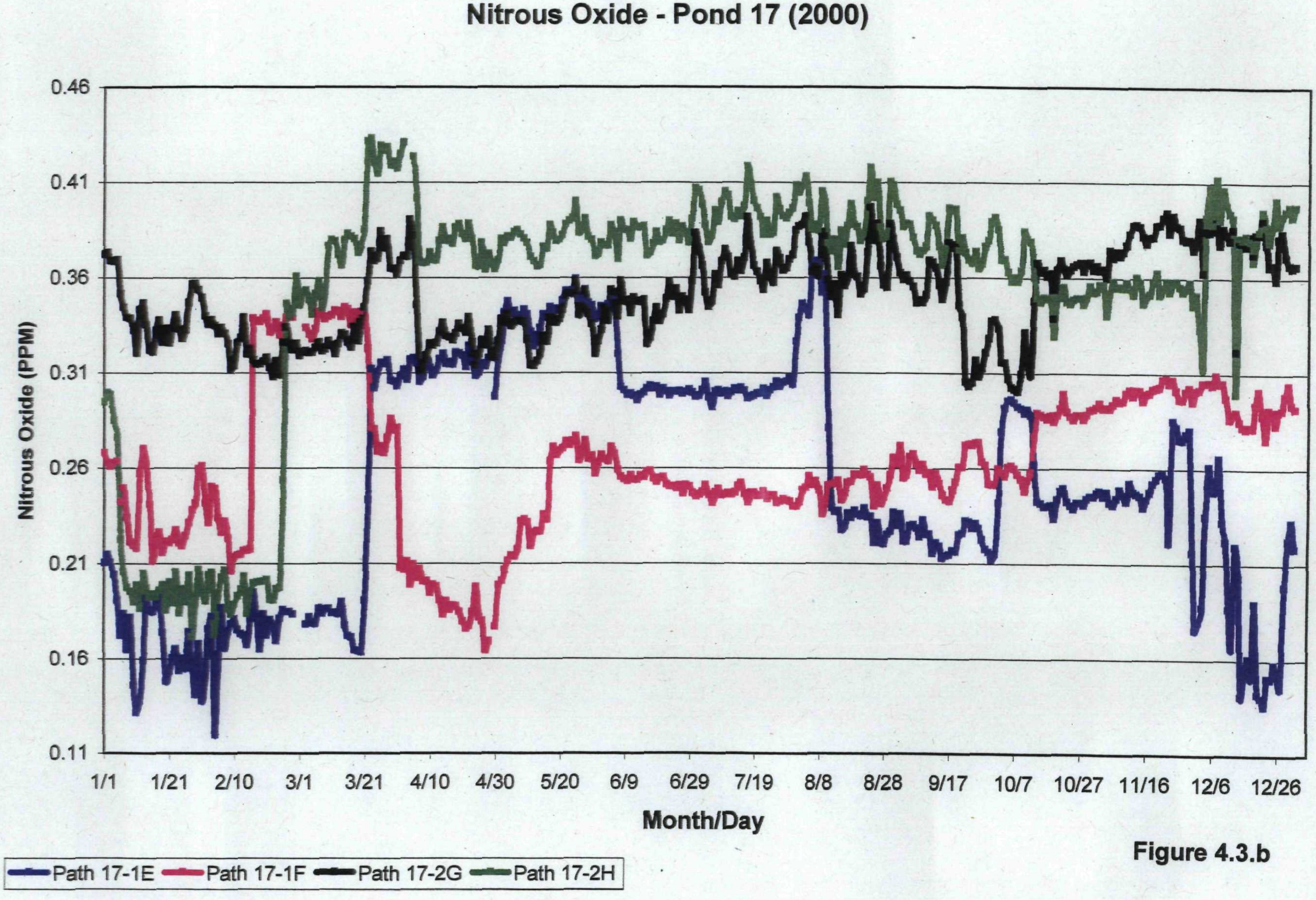
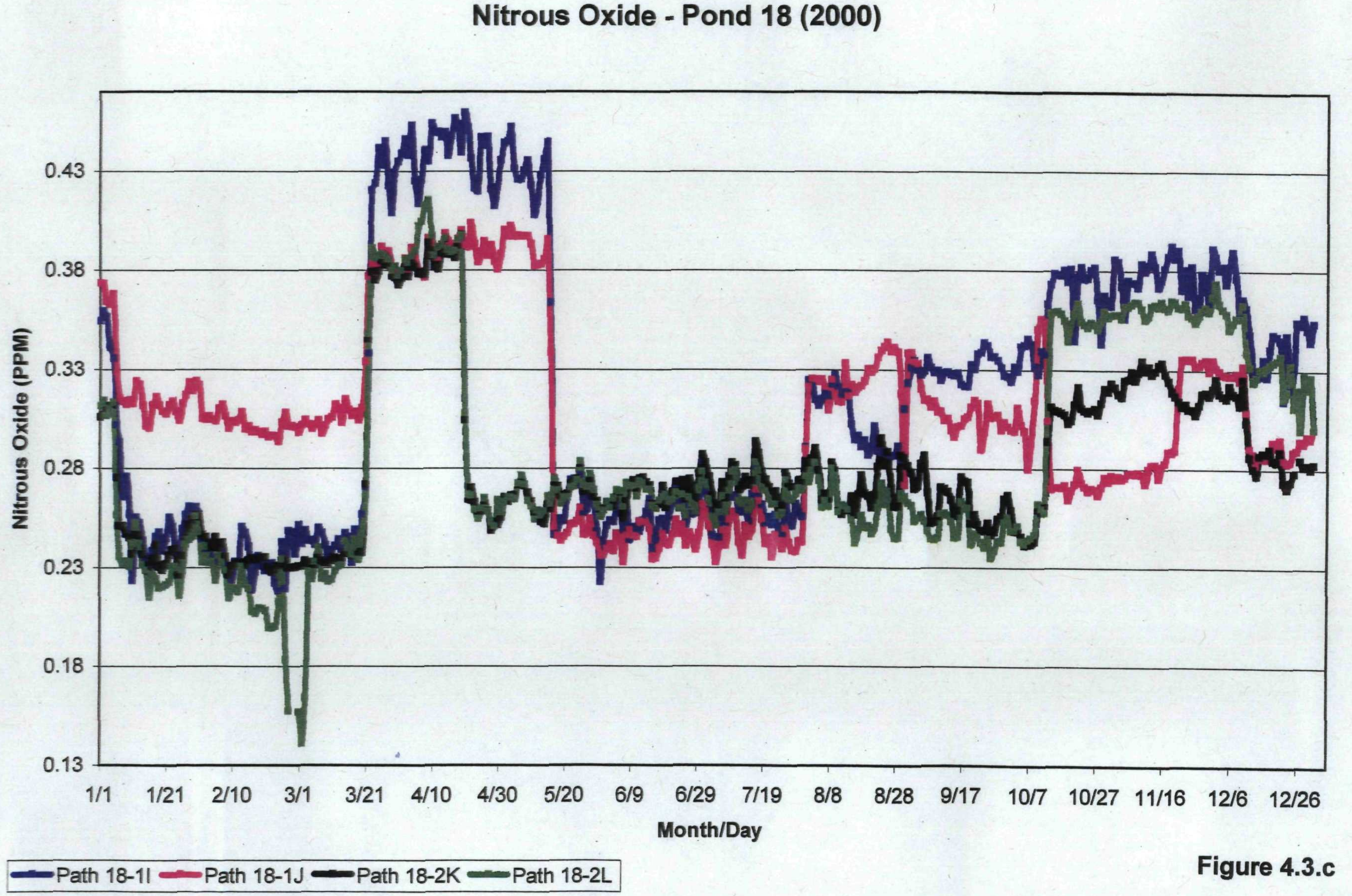

Nitrous Oxide - Pond 17 (2000)
0.46
0.41
0.36
0.31
0.26
0.21
0.16
0.11
Nitrous Oxide (PPM)
1/1 1/21 2/10 3/1 3/21 4/10 4/30 5/20 6/9 6/29 7/19 8/8 8/28 9/17 10/7 10/27 11/16 12/6 12/26
Month/Day
Path 17-1E
Path 17-1F
Path 17-2G
Path 17-2H

Figure 4.3.b



Nitrous Oxide - Pond 18 (2000)
Nitrous Oxide (PPM)
0.43
0.38
0.33
0.28
0.23
0.18
0.13
1/1
1/21
2/10
3/1
3/21
4/10
4/30
5/20
6/9
6/29
7/19
8/8
8/28
9/17
10/7
10/27
11/16
12/6
12/26
Month/Day
Path 18-1I
Path 18-1J
Path 18-2K
Path 18-2L

Figure 4.3.c

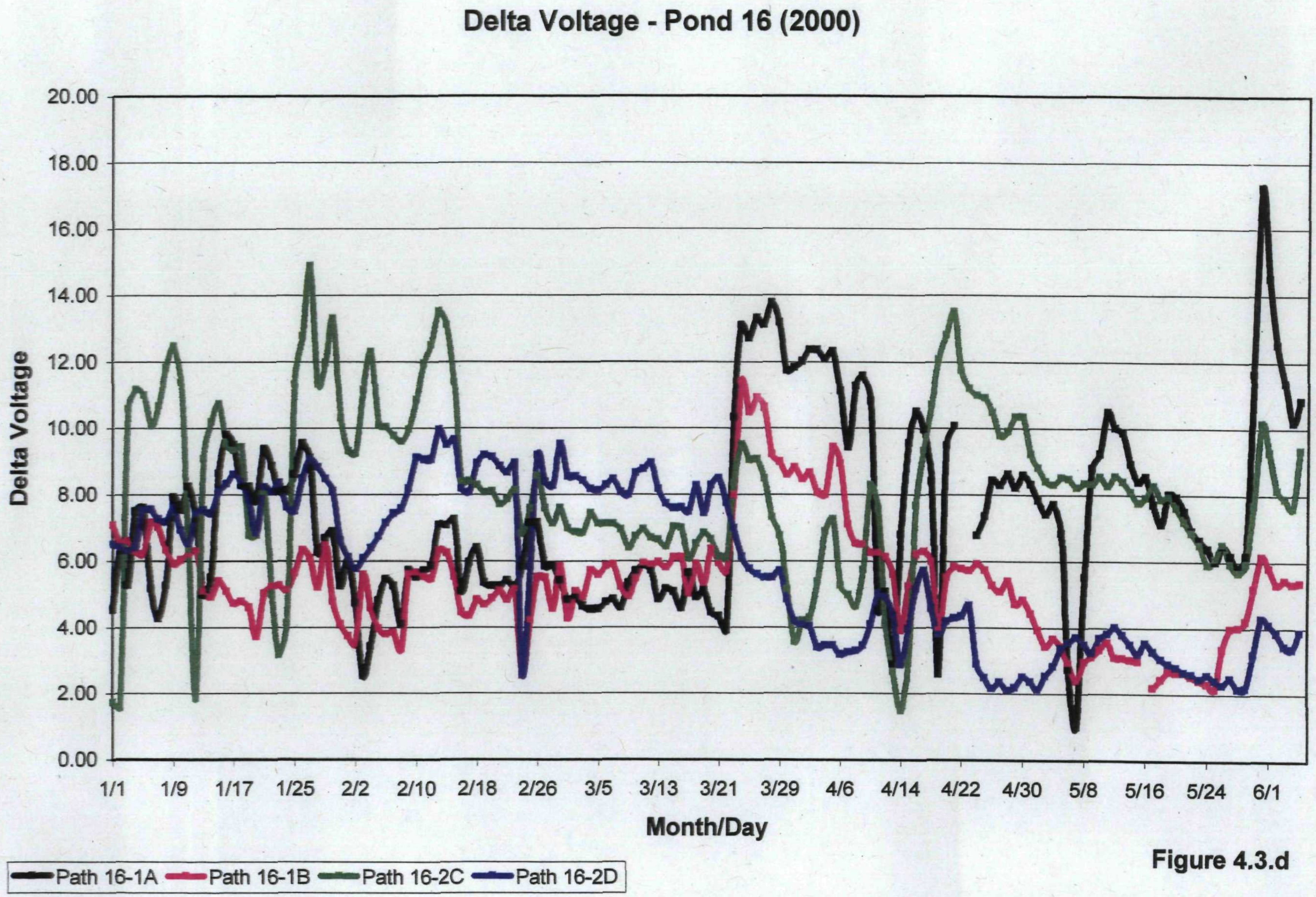

Delta Voltage - Pond 16 (2000)
Delta Voltage
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1/1
1/9
1/17
1/25
2/2
2/10
2/18
2/26
3/5
3/13
3/21
3/29
4/6
4/14
4/22
4/30
5/8
5/16
5/24
6/1
Month/Day
Path 16-1A
Path 16-1B
Path 16-2C
Path 16-2D

Figure 4.3.d

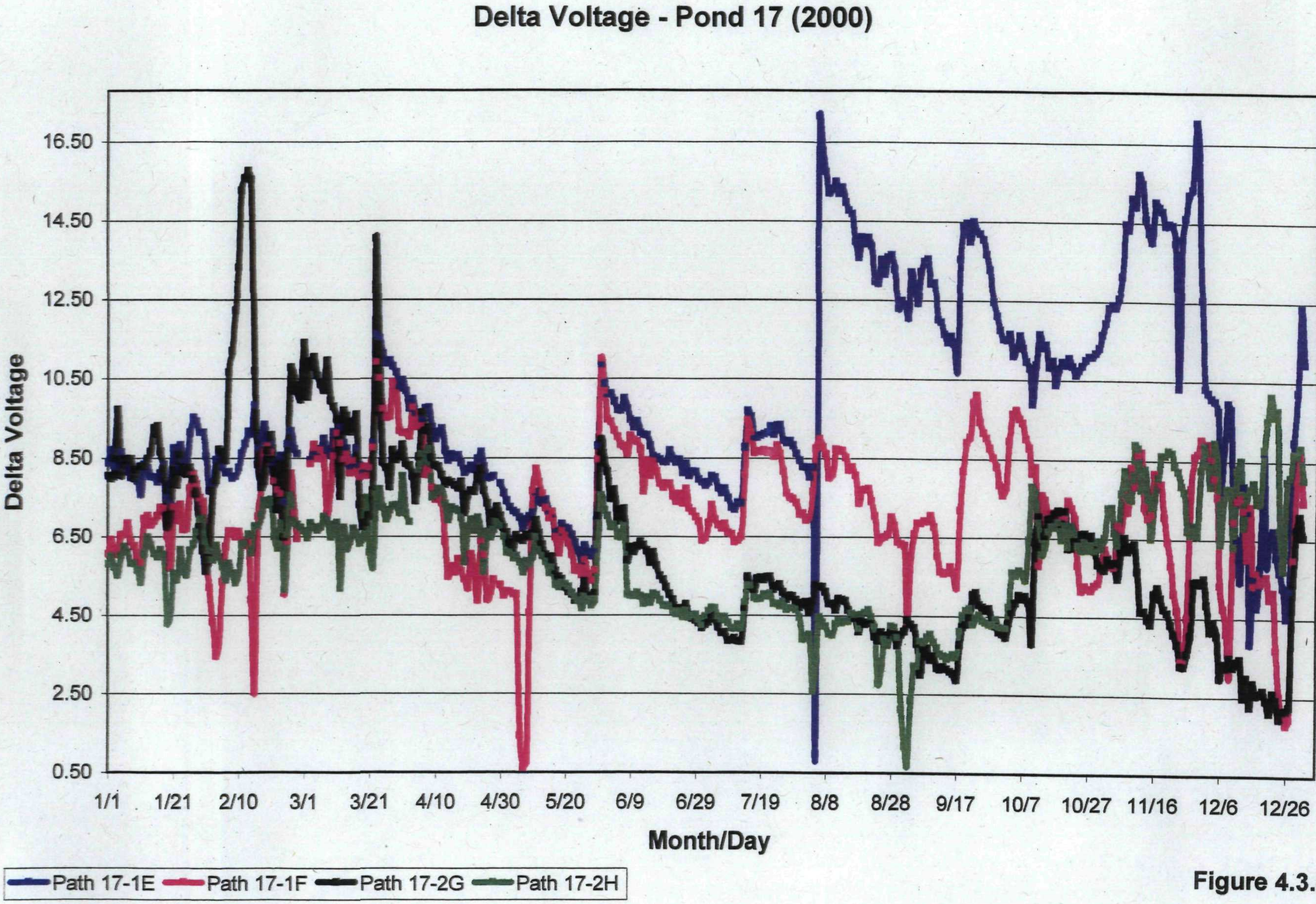

Delta Voltage - Pond 17 (2000)
16.50
14.50
12.50
10.50
8.50
6.50
4.50
2.50
0.50
Delta Voltage
1/1
1/21
2/10
3/1
3/21
4/10
4/30
5/20
6/9
6/29
7/19
8/8
8/28
9/17
10/7
10/27
11/16
12/6
12/26
Month/Day
Path 17-1E
Path 17-1F
Path 17-2G
Path 17-2H

Figure 4.3.e

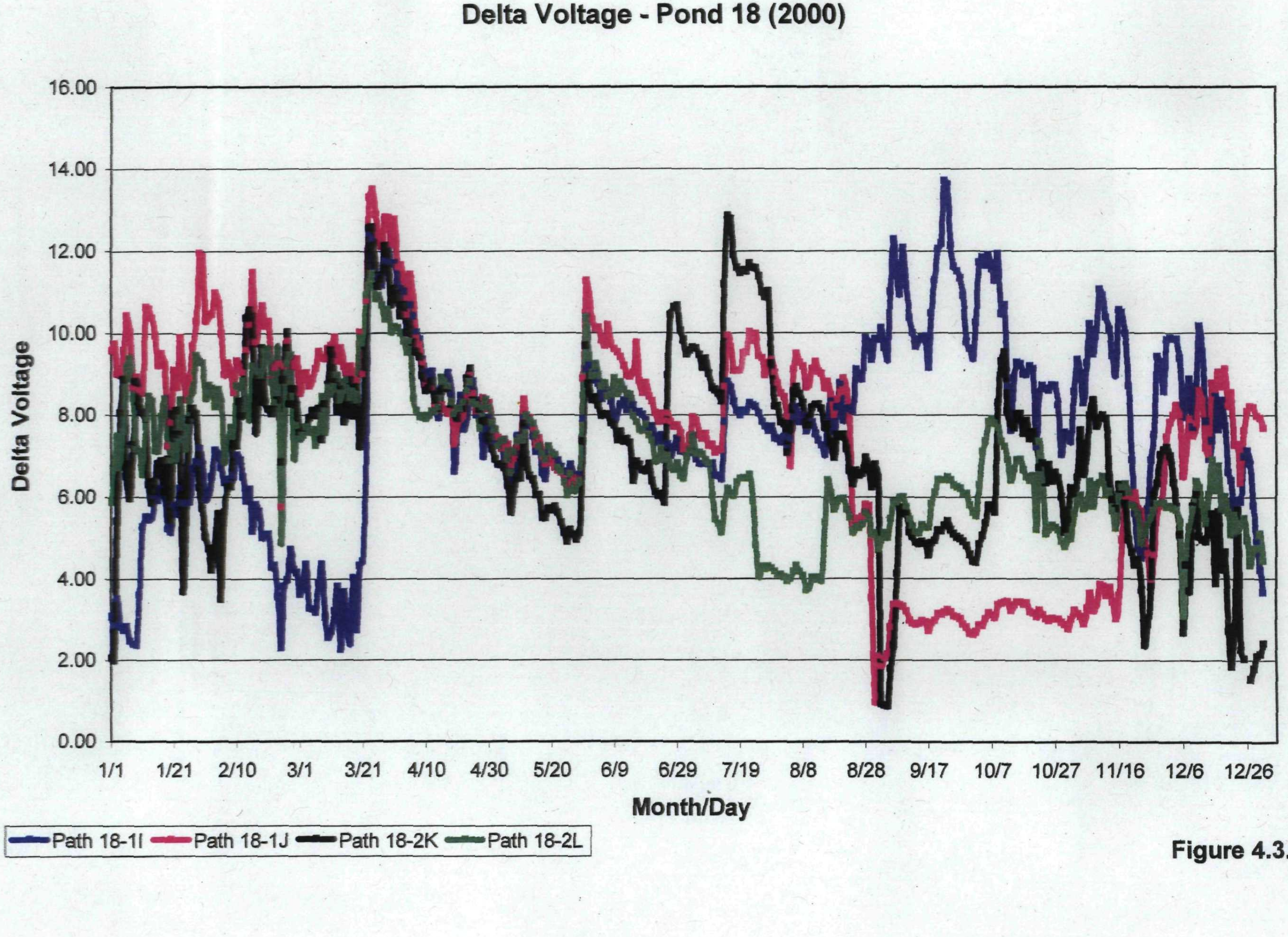

Delta Voltage - Pond 18 (2000)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Delta Voltage
1/1
1/21
2/10
3/1
3/21
4/10
4/30
5/20
6/9
6/29
7/19
8/8
8/28
9/17
10/7
10/27
11/16
12/6
12/26
Month/Day
Path 18-1I
Path 18-1J
Path 18-2K
Path 18-2L

Figure 4.3.f

August due to a damaged detector. The new detector that was installed allowed for a better signal voltage to be obtained. *See Figure 4.3.e.*

4.4 System and Performance Audit Results

System and performance audits were conducted in April and October of 2000. The results of the acceptance testing and system and performance audits are detailed in quarterly report documents during the time frame in which they were performed. On average, all ponds met or exceeded the project goals established for accuracy and precision. There were one or two individual paths that exceeded these goals slightly, but these cases were investigated and the outliers were explainable due to high target compound background fluctuations during the testing or short path length limited FTIR performance, (i.e. marginal resolution difference from $0.5cm^{-1}$). The systems audits showed no serious deficiencies in operation, and any minor deficiencies noted were generally rectified within a short time following the reporting of audit findings.